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ABSTRACT

This resource book is one of a series of three information resources containing ideas about instructional technology applications and how certain technology applications may have particular relevance to vocational education. It contains descriptions of some instructional technology systems applications that are currently in use. The cases focus on: (1) two-way interactive television; (2) a networked computer-based laboratory; (3) an integrated information technology system; and (4) technology and training in the nuclear industry. For each component of each system reviewed in the cases, a need is shown, followed by an application and the outcome of that solution. The notebook is designed to help vocational educators make decisions about which technologies to use in their instructional settings and how to apply elements of various systems to their situations. (KC)

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Instructional Technology Applications in Vocational Education: A Notebook of Cases

Illinois State Board of Education

Adult Vocational and Technical Education

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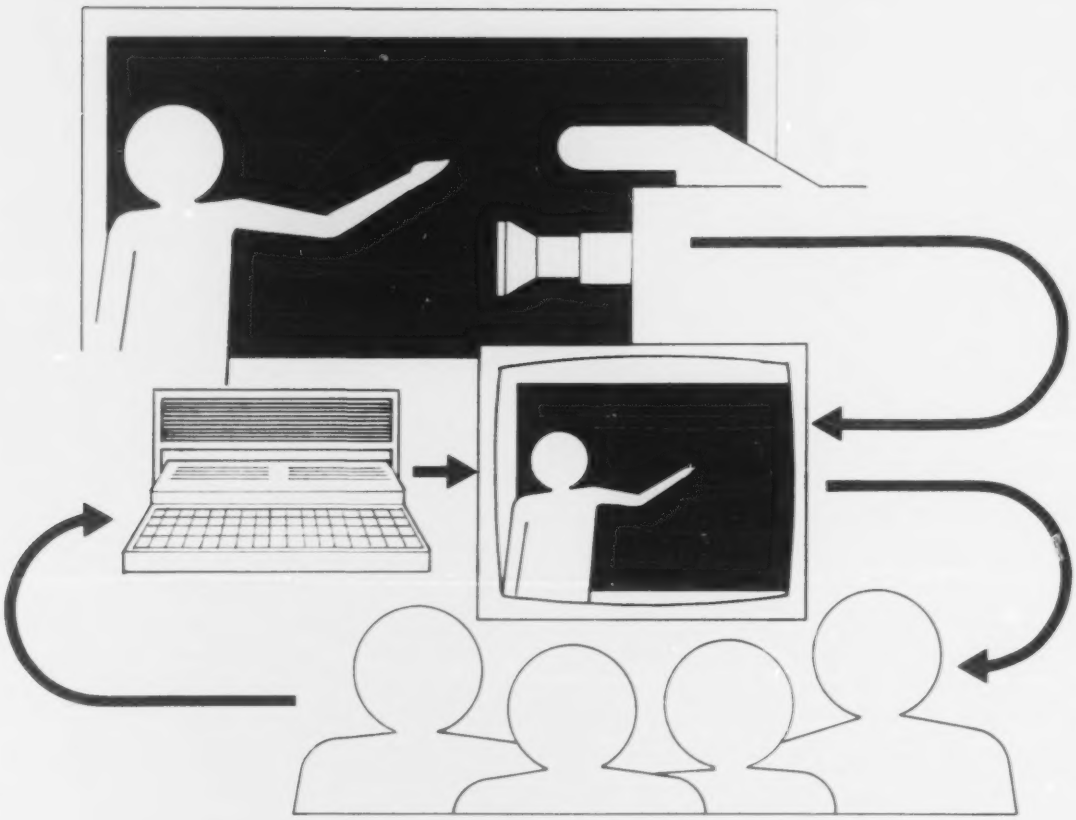

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Chapter 1

Introduction to the Notebook

From as far back as anyone can tell, people have been fascinated with great ideas, wondrous inventions, and far away places.

As a people, we love to play with ideas, ideas that are elegant, or compelling, or that project us out of the ordinary. The recorded history of civilization is filled with accounts of utopias, philosophy, art, and reasoning, great ideas that shape the way we view the world, and ourselves.

We are captivated by the inventions issuing from the minds of creative people, hard working people, lucky people. We are sometimes horrified by our inventions, sometimes delighted, sometimes relieved, but most often we are *curious* by what we see, and what we can do with what we have invented.

And of far away places? We are enthralled with the new, the unknown, the glorious, the frightening, and the different. We long to be where we are not. As a people, we have been explorers in a myriad of domains, from outer space, to inner space, to time, to the frontiers of our experience. Many like to physically travel, others prefer to dream of the far away.

Civilization has produced an endless number of people who have made it possible for us to contemplate great ideas, examine new inventions, and consider far away places. Some of these people have been fanatics, some dreamers, some just in the right place at the right time.

In that small corner of the world concerned with technology developments, and *instructional* technology developments more particularly, innovators have helped us dream, helped us consider new ways of thinking about and doing things. Visionaries have painted pictures of how education could be. Advocates have argued that technologies applied to education could help us deal with some of the issues we face. And we have had zealots who have proclaimed that the technological answer must be in the form of computers, television, radio, books, or numerous other solutions. As educators, we have had many dreams portrayed for our benefit; we have not, however, always seen the dreams come true.

By virtue of their responsibilities, and perhaps because of their daily experiences, educators are a pragmatic lot. They must be: it is one thing to dream, but quite another to face on a daily basis a classroom of children or adults. Educators have been sold solutions to problems, and yet the challenges persist. A certain level of cynicism inevitably surfaces, particularly as *technologies* of one sort or another are presented by various advocates as answers to all of the problems in education.

In spite of reasonable cynicism, or sometimes ignorance or fear, many educators remain open to suggestions of ways to improve what they do, or ways to make their services available to more and different kinds of people. Educators in general are open to the applications of instructional technologies, but educators want more than hype, more than empty promises. Educators want evidence that technologies being advocated for teaching and learning will work, bring results, make teaching and learning more effective and enjoyable. Educators want to "kick the tires" of technological possibilities, to see things actually working, to know if a technology will work in *their* setting. These wants are realistic.

Vocational educators are no different in these respects from educators in other fields. Vocational educators know and value pragmatic perspectives on teaching and learning. Vocational educators want to know if a technology works, with whom, and under what conditions. In fact, it could be argued that vocational educators have a *special* stake and interest in instructional technologies, for many vocational educators work with technologies as *content* as well as instructional delivery systems.

In the companion volume we have prepared (*A Sourcebook of Ideas*), we described a number of instructional technologies that might have potential for applications in vocational education. In general, we described in that volume what might be thought of as *individual* technologies, things such as microcomputers, or videodisks. These instructional technologies (hardware and software) are suitable for many uses in vocational education. In addition to these kinds of technologies, however, are new forms or combinations of separate technologies that may have considerable consequence for the future of teaching and learning. We have chosen to call these combined technologies instructional technology *systems*. The section on integrated information technologies in the Sourcebook is one example of a technology system. We felt it important to also alert vocational educators to some other forms of technology systems that we feel should be carefully examined for their potential relevance in vocational education. This *Notebook* is about some of these emerging technology systems.

Instructional technology systems tend to represent subtantially greater investments than do individual pieces of hardware or software. Technology systems require schools, as well as individual teachers, administrators, and students, to approach the activities of teaching and learning in new ways, or with different emphases. For some educators, instructional technology systems represent impossible dreams (or, in some cases, all too possible nightmares!); to other educators, instructional technology systems represent the kind of tools needed to overcome seemingly insurmountable barriers to quality instruction. Instructional technology systems frighten some, and excite others. One thing seems certain: instructional technology systems are definitely arriving, whether we are ready for them or not. In our judgment, it behooves vocational educators to be at least aware of some of these emerging systems, even if the systems in their current state seem neither feasible nor desirable.

It is with these ideas in mind that we have prepared *Instructional Technology Systems Applications In Vocational Education: A Notebook of Cases*. In this volume, we have collected information on a number of specific instructional technology systems which have potential applications in vocational education. Rather than describe these technology systems in a conceptual or abstract sense, we present selected *cases* of technology systems currently in use in a variety of contexts. We have not developed case studies of all (or even most) kinds of technology system applications. Rather, a few instances were highlighted for vocational educators as representatives of *kinds* of technology system applications. Our intent in these case studies is to stimulate your thinking of what might be done with such technology systems in your own setting.

To get you started thinking about cases of instructional technology system applications, we have prepared four rather lengthy descriptions of what we believe are creative and forward-looking technology systems. Briefly, the cases focus on:

- Two-way interactive television: Telesystems, Inc., located in Bloomington, Minnesota, has developed a very interesting two-way interactive television system that has fascinating possibilities for providing vocational education opportunities in a variety of contexts, including more rural areas where provision of some kinds of instructional opportunities can be difficult.
- Networked computer-based laboratory: Jostens Learning Corporation has developed a carefully planned, curriculum-based net-

work computer system that vocational educators may wish to examine for potential applications in vocational education.

- Integrated information technology system: As part of the California Model Technology Schools project, the Sacramento City Unified School District has created an exciting integrated information technology system for a number of its schools. This system, which utilizes computers, telecommunications, a variety of kinds of video technologies, and a substantial staff development program, provides a glimpse into what might be the classrooms of the future.
- Technology and training in the nuclear industry: We have also included a description of how technologies are being used for training in one kind of business, the nuclear industry. This fascinating look into instructional technology applications in the private sector offers some interesting ideas for vocational educators.

Again, we emphasize that the cases presented herein are not meant to be *prescriptive*, but rather illustrative of how technology systems might be used in the future in education in general, and in vocational education in particular.

The most common criticisms made by those who read descriptions of technology systems being applied in a particular context, such as the cases presented in this *Notebook*, are that "I could never use that technology system in my setting, because our situation is so different." Or: "These cases are fine for wealthy school districts, but in my District we don't have the resources needed for technology system applications like in these cases. The cases are unrealistic in terms of what I deal with on a daily basis." Fair enough. But what we suggest is that you, the reader, consider the cases we present here not with the idea that you directly and completely transfer any one of these cases to your setting, but rather that you look for ideas, or elements in the cases, that you might adapt for *your* own setting. Remember that these cases were selected because we feel they have some elements of the future in them, and are therefore worth looking at *in the present*. While the cases themselves are very real, and very concrete, concepts underlying the cases are of value to most readers.

With that introduction, we invite you to consider the cases of instructional technology systems applications presented in this *Notebook*.

Chapter Two

Two–way Interactive Television: The Tele–Systems Approach

Introduction

Without question, television has become a most important, if not *the* most important, medium in twenty–first century life. Television is now pervasive; in the United States, television sets are found in virtually all homes. Television is powerful: it has shaped the behavior pattern of individuals; it has changed the way we elect our leaders; it has profoundly influenced the way each of us views reality. Television is evolutionary. What began as a medium dominated by very small numbers of organizations called networks is now evolving into a medium that is influenced and controlled by a variety of individuals and agencies. Networks no longer hold exclusive power over the viewing habits of American citizens. Small video stores, cable television companies, and other entities have redistributed organizing and influencing powers over television, and have in many ways freed the American viewer from a monopolistic enterprise. Perhaps most importantly, television has always been a part of the lives of many of our citizens. In today's world, television, for better or worse, is part of the very fabric of the human experience, particularly for those individuals middle aged and younger.

Educators have long been interested in the potential of television for delivering instruction. Indeed, for years educators have attempted to exploit the television medium. Commercial broadcast television has provided college experiences, for example, through the 'sunrise semester.' Closed circuit and other forms of instructional television have been used in a variety of settings. Of late, the utilization of video cassettes and video for instruction has increased in classrooms and workplaces throughout America.

Along with the experimentation a line of research has developed which seeks to answer the question, "Can people learn through television?" The answer is consistently, "Yes! People can learn through television, and can do so very well." The question of whether television is better than live instruction is often raised, but it is probably a question not worth asking. Televised instruction no doubt has a place in an overall learning system, as does live and face–to–face instruction. Circumstances and situation–defined learning goals ought to dictate the choice of

television as an instructional tool or, for that matter, whether any other medium of instruction is appropriate. But questions about the use of television will persist. Television is a ubiquitous medium. Educators need to understand how it may be used for educational purposes.

Vocational educators exploring potential applications of instructional technologies for their programs are well advised to consider the possibilities provided by television. Indeed, vocational educators have a history of utilizing television in its various forms to improve the quality of vocational education. Television may extend vocational education opportunities to people who, without television, simply would not have access to good instruction in vocational education. Television lends itself well to demonstrations and to provision of visual experiences of a kind not easily obtained in a classroom setting. In numerous instances, television has worked its wonders for the good of vocational education.

Although many people have recognized the power of television as an instructional medium, there have been limitations. A primary limitation has been the one–way nature of television, since it is by and large not an interactive medium. The learner cannot communicate with the teacher via traditional television, and the passive nature of this type of learning worries many educators.

The quality of programming available on television is another concern of educators. Too often, those using television have endured the 'talking head,' a situation where an instructor simply lectures to the camera. Unless the instructor is a particularly brilliant performer, this form of television programming is dull and ineffective. However, costs involved in producing quality programming which takes advantage of production capacities of television, such as programming produced by Children's Television Workshop, are extremely high. As a result, relatively few creative programs are made available to educators, specifically vocational educators.

The *role* of television in the classroom creates additional concerns, which are most often expressed as fears that teachers will be replaced by television. In spite of large amounts of experiential evidence to the contrary, this fear persists and inhibits widespread use of the technology.

Recent developments, however, have raised interesting possibilities for using television as an instructional medium. Of particular interest are developments related to *interactive television*. Such television–based systems permit students to interact with their television teachers, students to interact with other students, and both students and teachers to interact with experts in given subject areas who are usually inaccessible to students. This case study portrays one such interactive television system currently being developed and marketed. The interactive system described in the pages to follow is not the only such system in existence, but is an excellent representative of the genre.

An Interactive Television System by Tele–Systems Associates, Inc.

Rationale for Inclusion as a Case

Recognizing both the power and the pervasiveness of television as a medium in American society, the authors have included in the *Notebook of Cases* an application of television as an instructional tool with potential for vocational education. In preparing this *Notebook*, the authors reviewed various approaches to the use of television. Most of these approaches are traditional in nature and do not show promise of overcoming limitations suggested in the introduction to this case. However, at a conference in Arlington, Virginia, a description was given of a new interactive television system. The author established contact with personnel at a small company called Tele–Systems Associates, Inc. The interactive television system developed by the company appeared to hold a great deal of promise for education in general, and for smaller rural schools in particular. The author arranged a site visit to corporate headquarters in Bloomington, Minnesota. Included in that site visit was an opportunity to observe the system operating in three small rural schools in southern Minnesota. Following completion of the site visit, which included lengthy interviews with key staff members at Tele–Systems Associates, a decision was made to include the interactive television system as one of the cases in the *Notebook of Cases*.

Why had the two–way interactive television system been created in the first place? A review of

descriptive literature about the system, together with conversations with corporation personnel, provided insights into the rationale for initial developments of the system. The rationale centers on two problems: rapidly diminishing learning opportunities for students in rural areas and teacher shortages in virtually all content areas. These two problems diminish opportunities for students to gain access to courses of study. The general reduction in operating funds available to schools and the scarcity of well–trained teachers in certain specialty areas are factors disproportionately affecting rural schools. Developers of the Tele–Systems interactive television system sought a way to provide high quality courses of study to students dispersed throughout rural communities, and to permit those students to study via television in a way similar to study in traditional face–to–face classroom environments. The hope was that emerging telecommunications systems and networks could be effectively used to interconnect schools and school districts. By connecting those schools using highly interactive television, a single teacher could teach a course to multiple schools simultaneously, and learners in each of the connected schools could interact electronically in a manner similar to a traditional face–to–face classroom. Students need to see and communicate with other students; the originating teachers need to see and communicate with students in each of the other schools; and, in the best of all worlds, students and teachers need to send materials back and forth via fax or other technologies to complement the instruction available via the interactive television.

Literature produced by Tele–Systems Associates describes advantages of two–way interactive television. For example, interactive television enables small, isolated schools to offer low enrollment, low incident classes that are often not economically feasible. Courses such as calculus, advanced levels of algebra and trigonometry, sciences, and foreign languages, become feasible through the two–way interactive television system. In addition, students may stay enrolled in their smaller home schools without being bussed long distances to regional schools. Teachers may grow professionally, for staff development programs also can be made available through the system. Rather than leaving schools because of enrollment decline, teachers may actually expand their positions within home schools by teaching subjects to a broader audience through television. Contrary to the belief that technologies will cost teachers their jobs, two–way interactive television may enable teachers to keep their jobs while learning new professional skills. The content of courses to be delivered by interactive television may also be delivered by traditional one–way television. Developers argue, however, that one–way television does not adequately simulate conditions of effective instruction. Drop out rates using one–way television programming are notoriously high. Unless students can interact on an on–going basis with their teacher and with other students, they will not achieve a desired level of quality. The rationale for two–way interactive television centers on both the ability of the system to deliver high quality, unique courses in primarily low enrollment, low incidence settings, and the capacity to deliver courses that facilitate individual learning through interactivity of learner with teacher and learner with other learners. Two–way interactive television systems may hold great promise for the delivery of *vocational education* courseware to populations that at the moment cannot receive such courseware.

Components of the Interactive Television System

At the simplest level, the interactive television system consists of two broad components: the classroom unit; and the means of communications connecting classrooms together. A brief description of each of these primary components is provided below.

Classroom units. In each school connected into the system, a classroom is constructed which contains basic equipment necessary to operate the interactive television system. In those sites currently using interactive television systems, ordinary classrooms have been used, or in some cases, rooms that had previously been used for conferences were converted for use as classrooms.

Figure 1 contains a drawing developed by Tele–Systems Associates to portray a typical classroom setting for their system. The elements in the classroom setting include:

1. Three television *cameras* are installed in the room. One camera faces the students and is normally mounted on the wall or on a tripod behind the teacher station. A second camera is hung from the

TWO-WAY INTERACTIVE TELEVISION CLASSROOM

– Suggested arrangement for basic instructional settings –

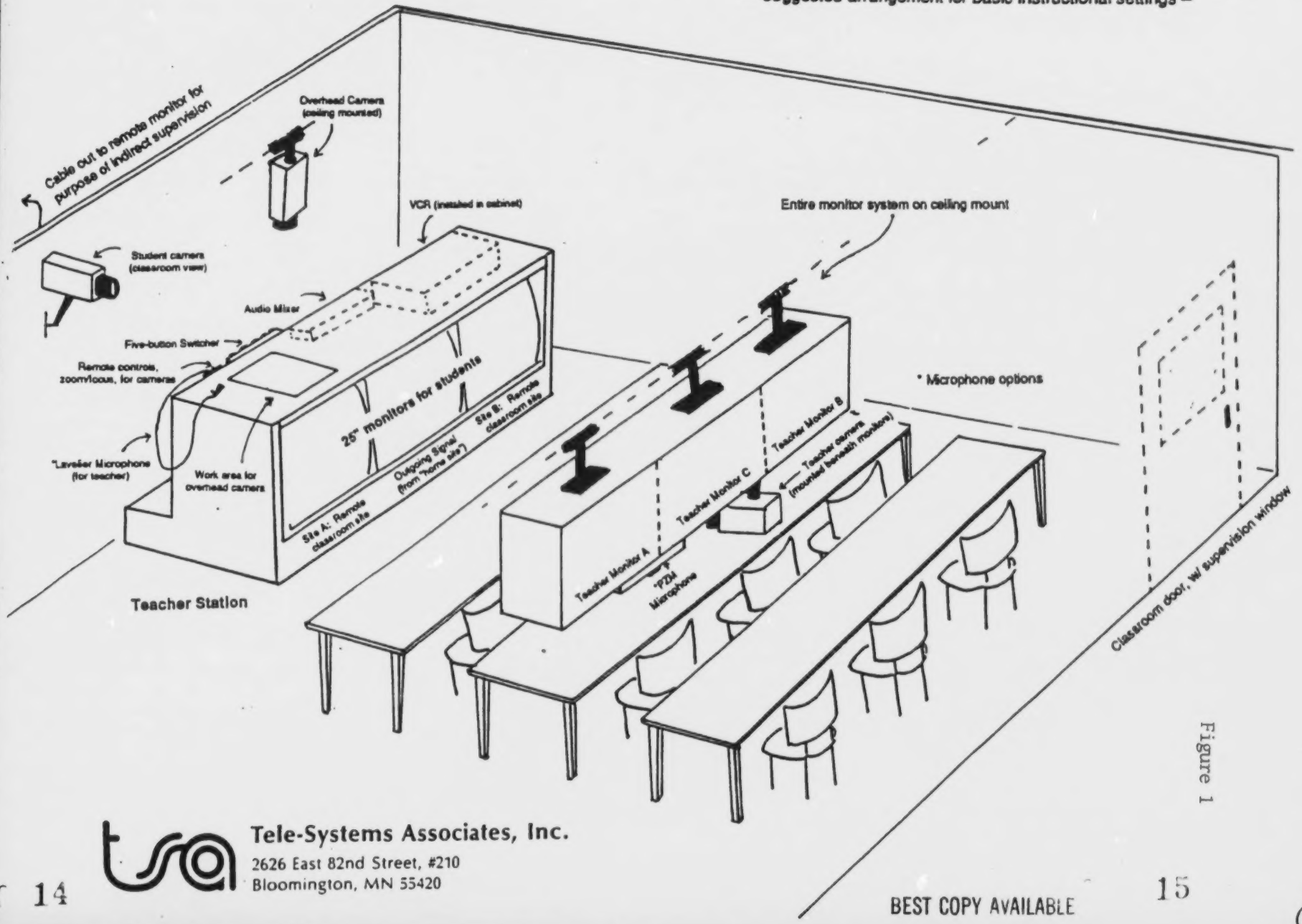
Cable out to remote monitor for purpose of indirect supervision
Overhead Camera (ceiling mounted)
VCR (installed in cabinet)
Entire monitor system on ceiling mount
Student camera (classroom view)
Audio Mixer
Five-button Switcher
Remote controls, zoom/focus, for cameras
25" monitors for students
Site A: Remote classroom site
Outgoing Signal (from "home site")
Site B: Remote classroom site
*Lavalier Microphone (for teacher)
Work area for overhead camera
Teacher Station
* Microphone options
Teacher Monitor B
Teacher camera (mounted beneath monitor)
Teacher Monitor C
Teacher Monitor A
*PZM Microphone
Classroom door, w/ supervision window

Figure 1

Tele-Systems Associates, Inc.
2626 East 82nd Street, #210
Bloomington, MN 55420

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ceiling and points at the teacher/teacher work station. Suspended from the ceiling directly over the teacher's work station is a third camera which transmits images the teacher uses to support various aspects of the instructional program. In a sense, this third camera acts as a modern day overhead projector. The camera transmits to other schools writing, pictures, or other visual displays used in teaching. Students may also use the projection capability to show their work to other students on the system.

2. Approximately six television *monitors* are placed in the room. Three of the monitors face the students. Three other monitors are suspended from the ceiling and face the teacher. From the students' point of view, they are able to simultaneously see the teacher, other students, or visual displays from up to three other classrooms on the system. Similarly, the teacher is able to view his/her three monitors to observe students in any of the other classrooms on the system.

A switching device is built into the teacher workstation. This switching device enables the teacher to control which camera operates at a specific time. The teacher may focus the camera on himself/herself when lecturing or leading a discussion; may project students in one of the classroom to other classrooms on the system; or may switch to the projective camera suspended from the ceiling. Thus, in any of the classrooms on the system, at any point in time, three different views of each classroom may be obtained by this switching device. In most cases, the switching device is controlled by the teacher. However, during the site visit conducted by the author, students (in those classrooms in which the primary teacher was not resident) worked the switching device as requested by the teacher convening the class.

3. *Microphones* are placed in the room at key spots to pick up both student and teacher conversations. Thus, all students in any of the classrooms can be heard by other students and by other teachers.

4. Additional equipment is also included in the classroom. Each classroom contains a VCR. Material played on the VCR may be fed directly into television monitors via the switching device, permitting teachers to use VCR–based materials in their instruction at any point. In addition, some system users have installed fax machines in the classroom, allowing students and teachers to send hard copies of classroom assignments or other materials to students or teachers in classrooms throughout the system. The system also provides access to video–disk, cable feeds, and microcomputers, should a school wish to use those technologies.

Communication technologies. A special consideration is the manner in which schools of this system will be interconnected. A maximum of ten schools can be linked in a given system; developers of the system, however, suggest that seven schools is a more realistic number. There are three primary mechanisms for connecting schools: coaxial cable, microwave, or fiber optics. The method of communication is a function of site characteristics. There is no single best way to accomplish the communications network.

At this point, a general description of the communication alternatives is provided. The following technical information was prepared by Tele– Systems to explain communication alternatives to potential clients.

1. Coaxial cable: Coaxial cable is a metal cable consisting of a conductor surrounded by another conductor in the form of a tube which can carry video, audio and data signals. More simply, this is called 'hard cable.' There is an assortment of equipment required for coaxial cable use: modulator, demodulator, converters and amplifiers.

The modulator converts video and audio signals into television signals (Ch. 2, 3, 4, etc.) for distribution over a cable system. The demodulator converts television signals received from the cable system into video and audio output signals. There is a modulator located at each interactive classroom site. The demodulator is at the headend, the location of the cable company tower, antennas, and other equipment. A converter at *each* site allows the reception of 50–60 channels on a television monitor. Coaxial cable systems function approximately 15 years before major rebuilding is necessary. Coaxial cable signals can be transmitted from one point to many points simultaneously. The maximum coverage distance is up to 25 miles. Longer distances are normally impractical due to maintenance problems and signal quality.

Although coaxial cable can be fully two–way interactive, it is limited by the number of channels on the cable. Two–way interactive services on coaxial cable are a function of the system amplifiers—not the cable. All modern amplifiers can be activated for two–way transmission. However, most systems are

limited to two or three two–way channels without major modification. Coaxial cable is not significantly affected by adverse weather conditions and is available in most communities with more than 1,000 residents.

2. Microwave: Microwave is a high–frequency radio wave used for transmission of audio, video or data through the air. One–way audio and video transmission is called simplex; two–way audio and video transmission is called duplex. Specialized equipment, particularly towers, large antennas and expensive cable are required for microwave transmission.

Microwave is directional. That is, signals are sent from point– to–point for up to 50 miles. Short range microwave systems are used for 5 to 7 miles. The distance is a function of the frequency, antenna size, transmitter power and receiver sensitivity. Receivers and transmitters are expected to function approximately 15 years. Maintenance costs are usually one to four percent of the construction cost of the system per year.

The greatest advantage of microwave systems is direct control of signal reception. Classes taught over a cable system, for example, may be viewed by any cable subscriber in that system. Although most educational institutions are not concerned with security or privacy, microwave does offer a more secure and private transmission. A disadvantage of microwave is limited channel availability and costs based upon the number of channels being transmitted.

3. Fiber optics: Fiber optics is the newest and potentially most efficient and effective of two–way interactive technologies. It is cable made of glass that transmits light signals instead of electrical signals. Each glass fiber, the size of a human hair, can potentially carry up to 100 video channels per direction. Transmission equipment now under production can transmit 24 video channels per fiber utilizing analog transmission methods.

Fiber optics has a point–to–point or point–to–multi–point coverage pattern that can reach up to 20 miles without repeaters (amplifiers) and much further with specialized equipment. As digitized video equipment becomes more sophisticated, educators will be able to transmit a video picture around the world with minimum loss of quality. Other equipment necessary for this type of system are modulators and demodulators at each site as well as optical transmitters and receivers. There are two types of optical transmitters and receivers: analog and digital. Costs for analog systems are currently $5,000 to $8,000 per channel transmitted plus an initial one–time cost of $15,000 to $20,000 per site. Digital transmitters and receivers are currently much more expensive. Preliminary studies indicate minimal maintenance problems with optical equipment. Because optical fiber has no amplifier between points, outside maintenance would only be required in the event of broken fiber. A 20 to 30 year life span is expected for current equipment.

Channel capabilities of this technology are limited only by number of fibers. The system may be expanded to include audio and data transmission. Fiber optics are completely unaffected by weather and electro–magnetic interference. An increasing number of utilities and telephone cooperatives are installing fiber optics systems to upgrade their telecommunications infrastructures. Hence, this technology will offer an attractive opportunity for education/business partnerships, thus lowering the cost of the system considerably for schools and businesses. However, negotiations have proved complex and time consuming.

Using the Interactive Television System

A description of the hardware and communication components of the interactive television system does not explain how the system works in classroom practice. In this section, a brief description is provided of the system in action.

The author observed the system operating in a three school network in southern Minnesota. Each school was a small high school in a rural setting which established a classroom for the interactive television system, modeled from the drawing in Figure 1. Working together, personnel from the three schools scheduled a number of courses via the system. Scheduling was a major task, as schools had to agree on common times for each of the course sessions. Agreement was hindered because the schools were on slightly different time periods.

A typical course offered through the system, such as Introductory Spanish, might work as follows: One teacher is designated as the instructor for the course. That teacher is located at one of the three schools

and actually appears in the classroom in that school. The teacher works primarily from the teacher workstation at the head of the room, but is free to move about the room as he/she desires. For purposes of this example, let us say the class convenes at 9:00 a.m. and runs for 50 minutes. The instructor for the course first makes sure all three schools are connected for the session. This is accomplished by looking at the three monitors that face the teacher (see Figure 1). The teacher asks the students in each of the schools whether they are ready to begin. Responses are heard from the students, and the teacher is able to see students in the two remote schools, as well as those students in her own room. The teacher begins the lesson in any way desired, using lecture, discussion, etc., utilizing the camera above to show written materials to the class. Students in each of the three schools are able to see the students in the other two schools on the monitors in their own classrooms. All students are able to hear comments, questions and remarks from students in any of the three classes. Students are able to direct questions at one another and to respond to such questions. On occasion, the teacher may want to leave the workstation and go among the 'live' students. In that case, the teacher simply switches his/her classroom camera to focus on the students, and the teacher is then visible while working with the students. The class proceeds comparably to any face–to–face class setting. On occasion, the teacher may ask students to send copies of their written work via the fax machine, which students are able to operate. The teacher may give specific assignments to individual students or may raise questions directed at any of the students in any of the three schools.

As an observer, the author noted that students did not seem concerned that they were operating in a television based classroom. They behaved as one would expect students to behave in any classroom. Some of this behavior, of course, causes a certain amount of concern for school administrators. In this particular Tele–System installation, all material being communicated back and forth through the system is carried via the local cable television company lines and is available to anyone in the community (including parents) who wants to view local cable television channels. This creates an interesting challenge for students and teachers alike!

This system requires teachers to make unique kinds of preparation. For the most part, however, teachers can adopt a style very consistent with the style they use in a traditional closed classroom. The interactive capabilities of the system permit a level of discourse with students that is nearly indistinguishable from face–to–face interaction. Presumably, it takes experience for teachers to learn to manipulate the switching capabilities in the system. However, such operating skills appeared very natural to the two teachers observed by the author. It is also evident that many, if not most, school subjects can be taught through the system.

Support Services Provided by Tele–Systems Associates, Inc.

Tele–Systems Associates, Inc., provides certain services to school districts interested in utilizing its interactive television system. While these services are specific to the system designed by Tele–Systems Associates, the services are worth mentioning in this case study, for such services are needed by a school district wanting to use any interactive television. In some cases, those services will be provided by the originating corporation, as is the case with Tele–Systems. In other instances, the services may need to be provided by another source.

Services in support of interactive television provided by Tele–Systems Associates may be roughly divided into three categories.

Feasibility Studies

Tele–Systems Associates will develop a feasibility study for school districts interested in exploring the possibility of using the interactive television system. This feasibility study encompasses both *technical* and *educational* logistics within a specific setting. Technically, estimates are needed of existing equipment, types of communications technologies to best employ, and recommended modifications for classrooms. Educational feasibility involves examining school district goals, needs for an interactive television system, and potential educational applications for such a system. The intent of a feasibility study is to ascertain the extent to which the development and implementation of an interactive television system is desirable

for the specific conditions being examined. The resulting report helps districts decide whether or not to move ahead with an interactive television project.

Implementation Study

If a preliminary decision is to proceed with an interactive television system, Tele–Systems Associates then conducts an implementation study. This study describes specific requirements for the system and cites negotiations necessary to make sure the system will work. In this phase, decisions are made for selecting specific communications technologies. Tele–Systems will help school districts negotiate contracts with cable companies, microwave systems, or other communications companies. Final plans for classroom modifications are also completed during this implementation study. The implementation phase involves Tele–Systems Associates in constructing classroom modifications and installing equipment for the system. The implementation services provided by Tele– Systems Associates insure that the system is properly installed and running. Of course, the participating school districts will need to do a good bit of planning and implementation work themselves; Tele–Systems Associates implementation studies help guide efforts to make the system a reality.

Training and General Consultation

Tele–Systems Associates recognizes the importance of preparing people to effectively use interactive television. The company provides a training program for teachers and administrators who will utilize the system. Figure 2 contains an overview of a prototypic training program to support the implementation of interactive television systems.

In addition, Tele–Systems will guide school districts in using the system once it is in operation. This may consist of responding to phone calls, sending information of interest to school districts, or in other ways providing general support for operation of the system. This consultation is highly valued by personnel in districts currently using interactive television systems.

These specific services may be unique to Tele–Systems Associates. In any case, feasibility and implementation studies, as well as training programs, should be conducted. Districts must procure these services in order to effectively use an interactive television system.

Costs of the Interactive Television System

Anyone considering use of interactive television for vocational education must necessarily be interested in the cost to obtain and run such a system. Once again, specific costs of an interactive television system will vary depending on system design, intended use, and other variables. As a means for providing general guidelines, cost estimates for Tele–Systems Associates interactive television system are presented here.

Costs of the interactive television system may be divided into two broad categories. The first category involves purchases of equipment or services from external vendors. The second category involves costs accrued by a district in developing and maintaining the system.

External Vendor Costs

Hardware or service costs from external vendors, in this case Tele– Systems Associates, Inc. and a communications company, may be divided into three categories:

1. Feasibility study. Tele–Systems Associates charges districts to conduct feasibility studies. In general, feasibility studies cost a base price of $3,500. For this fee, up to three school districts planning for a single system may receive an extensive feasibility report that outlines prospects for implementing an interactive television system. If four or more schools are involved in a project, Tele–Systems Associates generally charges $1,000 per district for the feasibility study.

2. Classroom and transmission costs. A difficult aspect of cost analysis for an interactive television system is the calculation of communications or transmission costs for the system. Transmissions

TSA's Integrated Approach to Staff Development:

Tele-Systems Associates, Inc., offers staff development and hands-on training to teachers, facilitators, and other school personnel who are involved in the use of two-way interactive television systems as instructional and communications tools. The following information outlines the components of inservice TSA provides to client schools during the educational coordination and staff development phases of system implementation*:

Educational Development and Classroom Coordination:

1. Course selection, coordination, and scheduling
   - assist with finalizing course plans for the network
   - develop planning sequence for on-going program development
2. Organization and management of interactive on-line classes
3. Adapting existing curriculum
   - teaching style
   - instructional methodologies
   - pedagogy and interactive television
4. Materials preparation
   - making effective use of graphics and design elements
   - interfacing other technologies (data, phone) with the two-way system

Educational Applications of Two-Way Interactive Television:

5. Interactive television systems: uses and potential
   - educational frameworks for cooperating districts
   - goal planning for the future
   - using available resources (information and partners within the community)
6. Information collection
   - research and development information materials (fact-file for educators)
   - facts and applications information for planning, expansion
   - TSA's newsletter for professional educators: ***"InterConnect"***

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Over . . .

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Figure 2 (cont'd.)

TSA Staff Development and Training, cont'd.:

Hands-On Training and Systems Use:

7. Interactive classrooms: equipment and utilization

   - introduction to the technology
   - maintenance and troubleshooting for teachers and facilitators
   - managing down-time and "technical difficulties" (preparation)
   - exploring expanded uses of the system (data transfer, computers)

8. Teaching and the interactive classroom

   - teaching style and on-camera techniques
   - managing the classroom (manipulatives, teaching materials)
   - managing "paper exchange" (homework, tests and quizzes, etc.)
   - teaching interactively (on-camera methods for enhancing contact with students at the remote sites)
   - humanizing the medium (making interactive television the "transparent technology")
   - managing discipline, motivation, and enthusiasm of students

9. Legal and procedural issues

   - teacher contracts, obligations, and scope of work
   - liability (educational, legal)

10. Evaluation and assessment

   - interactive television as an alternative teaching methodology (what the research says)
   - effects of integrating a two-way interactive television system into the schools

Training materials and inservice coordination are *developed individually* by TSA for each client group, integrating locally-identified needs and interests of the cooperative network. Training for teachers includes hands-on instruction and a copyrighted teacher's manual of techniques, research, operations and trouble-shooting guides for the classroom, and many other essential information collections for staff and directors of two-way interactive television systems. All TSA training materials are proprietary to the client schools.

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* *TSA considers tailored, hands-on **training and on-going staff development** to be crucial elements in assuring the success of a two-way interactive television system. To obtain more detailed information regarding TSA's training program for ITV teachers, please contact Linda Lloyd at TSA: 612/854-6080.*

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costs tend to be the 'big ticket' items in the system. Tele–Systems Associates has attempted to provide guidelines for costs of classroom hardware and communications technologies. Figure 3 contains information provided by Tele–Systems Associates to prospective clients.

Information in Figure 3 is based on two school districts linked together, each utilizing one interactive television classroom. Figure 3 lists five assumptions that are made for this example. Readers should examine those technology assumptions carefully to conclude whether their school districts reflect the guidelines of those assumptions. Figure 3 also describes what an interactive television system linking those two prototype schools might cost, given three different means of communications: fiber optics, co–axial cable, and microwave. A significant difference occurs in cost, depending upon selection of the communications technology. Fiber optics, the most expensive option (a total cost of approximately $117,000), stands in contrast to the use of microwave systems (total cost of approximately $41,000). Numerous trade–offs among these three communications options should be expected, as is reflected in the cost. Other consumer considerations include projected maintenance costs, lifespan costs, and costs for expanding the system in terms of number of channels of availability. The average cost for developing and installing an interactive television classroom is between $10,000 and $15,000.

These total costs would be divided by the number of districts participating, in this case two. Economies of scale might be achieved for each additional district, but costs represented in Figure 3 should be viewed as the general costs for establishing and maintaining hardware and communications of the system.

3. Training and general consultation. Tele–Systems charges for training and general consultation. These costs will vary depending upon requirements and expectations of participating districts.

Within–District Costs

In addition to costs charged by external vendors, school districts participating in an interactive television system should plan for certain additional costs, such as the following:

1. Personnel costs. School districts will need to provide instructional personnel to work with the system. In many respects, these costs should not be viewed as costs additional to normal district costs, as teachers working through the interactive television system would receive salary as if they were teaching in traditional classrooms. In some cases, districts may wish to augment personnel salaries. Each district should establish policy concerning this matter, as there could be personnel costs unique to the interactive television system.

2. Research and development costs. School districts may decide to conduct development projects related to the use of the interactive television system or may undertake research efforts to support that system. These costs should be calculated into the overall budget for the interactive television system. For example, districts may wish to develop visual materials to support the instructional program offered by interactive television. As another example, the district may wish to acquire video tape or video disk materials that are especially suited to the interactive television system.

3. Additional equipment. Some districts may wish to augment the basic classroom set–up by adding hardware such as fax machines, microcomputers, or laser disks. These costs go beyond the base price of the Tele–Systems Associates classroom configuration.

4. District sponsored training. In addition to the basic training provided by Tele–Systems Associates, individual districts or systems may wish to provide teachers with additional training sponsored by the district. Such training costs also need to be configured into overall costs for the interactive television system.

As is true in the implementation of any technology, school districts contemplating procuring an interactive television system must look both at initial capital costs, and at recurring costs. These costs need careful consideration. Too often, districts have made large investments in technologies but have not thought ahead to the nature of recurring costs. In many of those instances, the recurring costs become prohibitive and districts cease using an expensive technology system. Careful planning, aimed at providing a long–range picture of financial obligations, is a critical part of implementing a technology system such as an interactive television system.

Two-Site Prototype Examples

The following information illustrates the costs for general comparison purposes for the construction of a two-way interconnect for audio, video, and data transmission. These cost figures apply only under the conditions cited below. Life span of the system, maintenance costs, and expansion data are subjective and can be considered correct only within these specific applications:

Technology Assumptions:

1. The two schools are exactly seven (7) miles apart and are adjacent to a paved roadway where rights-of-way are available.
2. Topography varies by less than twenty (20) feet between sites.
3. FCC or state PVC rules and/or regulations have not been considerations in the development of this model.
4. Prices are considered *average* for equipment and labor, not allowing for "special situations" or for cost overruns.
5. Expansion of this example to include additional sites by simple multiplication of these costs is not recommended, as many other factors will realistically figure into an actual school setting.

OPTIONS:

Fiber Optics: Materials would include one pair of single-mode fiber optic equipment (buried cable), for one (1) channel of full-motion video with audio (and data capabilities) transmitted from each site, including classroom/studio equipment.

Materials and labor for fiber:	$ 63,000
Analog video transmission equipment (installed):	$ 35,000
Classroom/Studios (2) installed:	$ 19,000
	$117,000

TOTAL: $117,000 divided by two school sites = $58,500 per district.

Coaxial Cable: Materials would include seven (7) miles of .750 cable placed overhead on existing utility poles, spacing amplifier to use only VHF channels and sub-split returns. Low cost mod/demods have been selected for this budget.

Cable and labor:	$ 48,000
Modulators and demods:	$ 3,800
Classroom studios (two) and installation:	$ 19,000
	$ 70,000

TOTAL:$70,000 divided by two school sites = $35,400 per district.

more . . .

Page Two: Prototype examples

Cable systems, other considerations:

Maintenance = 5% per year
Expansion to four (4) channels at $3,000 each (duplex)
Life span of equipment = 10 to 15 years
Network is expandable to a practical limit of thirty (30) miles

Microwave: Materials include 4-foot antennas, receiving cable, one (1) channel transmitter and receiver, and short "stub" towers. Signals are not modulated.

Microwave equipment (23 GHz)	$ 16,800
Towers:	$ 5,000
FCC Fees:	$ 1,000
Classroom studio (two) and installation:	$ 19,000
	$ 41,000

$41,000 divided by two school districts = $20,500 per district.

Microwave, other considerations:

Maintenance = 3% to 5% per year
Expansion to three (3) channels at $15,000 per channel (duplex)
Life span = 12 to 15 years
Network is expandble, depending upon numerous technical factors.

Please contact Tele-Systems Associates, Inc. (TSA) for more information about system designs and costs for development and maintenance of interactive networks for schools.

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Costs must be differentiated from sources of *funding*. In some instances, initial and recurring costs of an interactive television system might be partially financed through partnerships with local businesses and industries. Grants may be obtained to help finance the cost of operation. In some cases, special title or chapter funds might provide financing for the system. School district personnel may be very skilled at locating a myriad of sources of funding; certainly, those skills are valuable for obtaining and implementing an interactive television system such as that developed by Tele–Systems Associates, Inc.

Possible Uses of Interactive Television for Vocational Education

Vocational educators might look to interactive television for similar reasons as educators in other content areas. That is, interactive television is a system that can provide instruction in virtually all content areas. The implication of this generalization is that interactive television is likely to serve a variety of purposes in any school setting, including purposes held by vocational educators. Given that general orientation, a number of very specific applications for interactive television may be suggested for vocational education:

1. Interactive television may be an effective means of delivering specialized courses in vocational education to districts or schools that normally would not have access to such courses. Many schools in rural areas are not able to offer specialized courses in vocational education because enrollments are low, thus making it impossible to hire and maintain specialized instructors for courses that enroll only a few students. Through the use of interactive television systems, districts within an education for employment system can share specialized course resources, thus making opportunities available to a few students in each of several districts.
2. Districts connected together through interactive television may be able to more effectively share specialized resources within an education for employment system. This point is basically an extension of the first use mentioned above; in this instance, districts might be encouraged to share parts of courses with each other. That is, each district may be offering its own course in business education, but for parts of that course, where certain expertise and resources may be possessed in one school and not the others, those special resources can be effectively shared with all schools of the education for employment system. Another example would be if one district has some particular equipment not possessed by the other districts, parts of courses related to that specific equipment could be effectively shared across the districts.
3. For some aspects of vocational education, students may need exposure to specialized experiences, such as viewing a particular kind of demonstration. These specialized experiences may not be available to students, particularly in smaller, more remote school district areas. Through the use of interactive television, students may gain access to such specific experiences.
4. Interactive television systems might facilitate cooperative projects among students located at remote sites. That is, students in three different districts might gather via the interactive television system to complete a research or development project. The interactive television system might allow grouping of students by interests. By comparison, a single classroom might not contain sufficient students with shared interests to form a working group or partnership.
5. The interactive television system may permit specialized training opportunities for teachers spread across a number of districts. Too often, teachers are not able to gain specialized training because there are not enough teachers in any one district to warrant the training. The interactive television system can bring a number of teachers together from multiple districts, thus increasing possibilities for staff development programs in specialized

vocational education areas. In addition, interactive television systems may provide an on–going networking or support system for teachers in vocational education. In smaller schools, vocational educators have no content colleagues, as they are the only ones teaching in a certain area. Teaching can become an isolating activity under those conditions. The interactive television system will permit a higher level of interaction among teachers with common interests in an education for employment system.

The preceding examples of interactive television for vocational education may be viewed as traditional uses of such a medium. This is not to denigrate the importance of these activities, but simply to suggest that the activities listed above are not without precedence. However, some creative new uses might be made of interactive television in vocational education settings, such as the following:

6. Vocational education students might be linked up to actual workplace settings if a portable or remote version of the interactive television system equipment could be installed in unique workplace environments. This would permit students to be electronically bussed to actual workplace settings, where they could see certain occupations undertaken in real settings.
7. Similarly, experts could be electronically brought to the classroom via interactive television. Students could gain access to people whose expertise normally would not be available in a traditional classroom. This might provide creative new opportunities for learners to gain insight into various issues related to vocational education.

Chapter 3

Integrated Learning Systems: The Jostens Learning Corporation Approach

Introduction

*It is an understatement to say that people are ambivalent about the growing computer presence: we like new conveniences (automated bank tellers, faster supermarket lines), but on the eve of a new era we, by definition, do not know where we are. The changes have been rapid and disquieting. We are ill at ease even with our children, who are so much at ease with a technology that many of us approach at arm's length. They take it for granted. To them it is not a new technology but a fact of life. They come home from school and casually report that they are 'learning programming.' The comment evokes mixed feelings. Parents want their children to have every advantage, but this new expertise estranges them. It seems to threaten a new kind of generation gap that feels deep and difficult to bridge. (Turkle, S. (1984). **The second self: Computers and the human spirit.** New York: Simon Schuster, Inc. p. 65)*

Sherry Turkle has eloquently expressed what many adults feel: a great ambiguousness about computers. We know that computers touch most aspects of our lives, yet many of us harbor mixed emotions about such technology intrusions. Computers increasingly reach out to children in schools, yet few teachers have integrated computer technologies into daily instructional strategies.

The *Sourcebook*, a companion volume to this Notebook, includes a section on the possible uses of microcomputer technology in vocational education. Microcomputers have been predominately applied in classrooms as 'stand–alones,' that is, as machines that operate independently of one another. Furthermore, most applications of microcomputers have focused on software programs that were not designed for a particular curriculum nor to match specific instructional strategies. This does not mean that all existing software programs are poorly designed or that current software is useless in implementing existing curricula. Teachers and learners have experienced ample success with current

microcomputer hardware and software. These successful ventures have fostered more *networking*, (connecting technologies together to increase applications) and experimenting with new kinds of learning projects. Vocational educators may find many good ideas in the early experiments of pioneers who first tested computer based instruction. Those ideas can be dusted off and tried in new contexts within vocational education.

There is, in addition to the older experiments, a new generation of learning systems taking shape. Called by a variety of names and offered by a growing number of vendors, *integrated learning systems* are beginning to emerge for the school environment. Integrated learning systems, as the name implies, offer carefully designed and developed instructional program that features a curriculum package or set of instructional strategies. The intended use of these learning systems is not as a stand–alone product, but rather as comprehensive, integrated curriculum–based learning programs. Integrated learning systems use microcomputers and related pieces of hardware, but they are used in different ways than microcomputers have traditionally been used in schools.

An integrated learning system developed by Josten Learning Corporation (formerly Education Systems Corporation) is described in the following narrative. This educational technology system should be viewed by readers differently than stand–alone (or even networked) microcomputers. The Josten system was conceived as an integrated learning system.

For purposes of this Notebook, a clarifying point is needed for the Josten learning system. To date, most of the applications of this learning system have been at the elementary school level. How, then, will vocational educators, who function primarily at the secondary and adult education level, find relevance to their teaching situation in this case example? While the Josten system has functioned primarily at the elementary level, its underlying concept offers many possibilities for use at secondary levels, including vocational education. Josten Learning Corporation initiated their developmental efforts at the elementary level, but is currently exploring areas germane to secondary vocational education. We urge readers to envision the concept undergirding the Josten learning system as a possible contributing element to their own teaching situation.

We are not *advocating* this particular integrated learning system over other systems available to the the education market. Alternative systems exist. We believe, however, that the Josten system has proven its qualities through considerable 'on–line' experience. It represents a powerful example of this kind of instructional technology system with several possible uses in vocational education.

The Josten Technology System

The Josten learning system may be described in three segments: *hardware, instruction, and support.* The following narrative describes each segment. [Note: The authors have referred to materials prepared by Josten to describe this system. These materials (information brochures) may be obtained by writing or calling Josten. Direct quotes from Josten brochures are italicized in the text. Readers should not equate use of materials from the corporation as a direct endorsement of this company's product!]

Hardware

Hardware and systems software of the Josten learning system include microcomputers, network software, CD–ROM (Compact Disc, read–only memory), 16 color technology, animation, music, digitized human voice, and mouse and keyboard input devices. Josten regards their system as a sound investment in technology:

> *Anticipating the future is central to the Josten technology philosophy. We understand the need for your district to implement a technology plan that responds to the current and future learning needs of students.*
>
> *In response to this need, Josten has developed the integrated learning system (ILS) – a powerful combination of comprehensive software curriculum, the latest in computer technology, and a built–in management and reporting system.*
>
> *Josten has rejected a strategy of dependence on specific hardware – primari-*

ly expensive and impractical business equipment – in favor of industry–standard microcomputers, more suited to the educational environment.

The goal of Josten is to give each district maximum flexibility in choosing a hardware configuration for networking the Josten Curricula. Use of standard microcomputers allows a district to:

- *Maintain compatibility with current hardware;*
- *Use computers as stand–alones for other purposes as desired;*
- *Incorporate third–party software into the Josten Management System.*

Because the Josten system runs on industry–standard microcomputers, maintenance is easier and less expensive. This allows for local service and the efficient turn around needed.

Currently the Josten Curricula supports MS–DOS, PRODOS, AND QNX operating systems.

By using industry–standard microcomputing equipment, Josten allows school districts to capitalize on previous investments in microcomputer technology, an issue of growing concern to many districts. Existing microcomputers may need alterations to fit the Josten system, but initial investments are protected to a considerable extent.

The Josten system is generally arrayed in a single laboratory setting. This setting includes teacher and student workstations, a network that connects and renders computers functional as a system, and CD–ROM technology. As Josten perceives it:

One of Josten's most exciting innovations is the application of compact disc, read–only memory (CD– ROM) technology to the integrated learning system. Josten's entire K–8 curriculum fits on a five–inch compact disc which can serve as many as 40 workstations with the same efficiency of a more costly disk. Introducing the CD–ROM as an alternative file server effectively reduces the cost of an average system by more than $10,000.

Hardware components of a Josten learning system might consist of 30–35 student workstations, each of which contains a microcomputer, a set of earphones, a CD–ROM drive, a mouse, and optional student peripherals. Student workstations would be connected via a network to a file server and a teacher workstation. The system cannot be adequately described without mentioning the instructional and instructional management materials and tools available to the users.

Looking at the system through the eyes of a teacher:

From a user perspective, system transparency and reliability are key. A complete system of up to 40 work stations can be set up and running within 48 hours. Initial setup of the instructional schedule is quick and easy, and system use requires no special knowledge of computers and programming. This reduces your teacher training time and allows that time to be focused on integrating classroom and computer instruction.

Because the host system communicates with the student workstations in real time, individual lessons for an entire class can be downloaded in the time it takes to exchange two classes in the Josten lab.

A new lesson for a specific child can be delivered in less than 20 seconds. Or the teacher can select a single lesson for all students. Moving students to different workstations to accommodate enrollment changes is also easy, and is accomplished without interruption to the instructional schedule or work of the students as a whole.

Without teacher intervention, the Josten System automatically delivers prescribed lessons, ends the sessions at appointed times, and collects and stores student results. Reports of student progress are immediately available to the teacher on request.

The preceding description contains an obvious marketing cast, but even with that caveat, the perspective on the technology system suggested above raises interesting possibilities for managing individualized and/or cooperative learning activities.

And from the learner's point of view? Josten proclaims:

Josten's technology is completely transparent to your students. The user–friendly system greets each individual by name as he or she approaches the computer. There is no swapping of disks, no technical commands – no waiting. Pressing any key launches the student into a personalized lesson. Clear voice, icon or text directions make easy work of guiding and branching the student through each step of the way without distracting from time on task.

The preceding narrative contains several assertions regarding the Josten system's capabilities from a student's point of view. This perspective raises empirical questions that can only be addressed through systematic evaluation. User–friendliness and responsiveness are sought–after characteristics of all technology systems. Josten Learning Corporation has made significant progress toward these ideals.

Instruction

The hardware employed in the Josten learning system is substantial, but not exceptionally flashy, unique, or exotic. The important features of the Josten learning system, or of any integrated learning system, are its instructional aspects. Integrated learning systems should not be sold on the basis of the hardware configurations alone, but rather on the quality, functionality, attractiveness, and effectiveness of concepts presented through the system. The hallmark of integrated learning systems is their commitment to providing a curriculum, rather than a collection of unrelated educational programming. School districts that purchase an integrated system buy a curriculum which contains content, instructional and assessment strategies, and a means of managing the learning and teaching processes with the system. This presents a challenge to a school district—determining if curriculum embedded in an integrated learning system is compatible with the desired curriculum the district wishes to offer.

Josten Learning Corporation has selected certain content areas (e.g., reading), to identify and develop instructional objectives and relevant content. Instructional strategies are matched to content so that the hardware capabilities are applied to effective teaching of content. Extensive design and development processes were undertaken by Josten to create their programs. Results of this design and development process may be reviewed by examining content areas. The following example (middle school mathematics) is taken from Josten 's description of this subject area and level.

Middle School Mathematics: An Example of a Josten Instructional Program

Focus

The Josten Middle School Mathematics Curriculum is a comprehensive, yet selective program for grades 6, 7, and 8, structured and sequenced to effectively complement basic instruction. The lessons also specifically incorporate the priorities of the National Council of Teachers of Mathematics for the 1980s:

- Problem solving should be the focus of school mathematics
- Basic skills in mathematics should be defined to encompass more than computational facility
- Mathematics programs should take full advantage of the power of calculators and computers at all instructional levels

The Josten Middle School Mathematics Curriculum addresses these priorities by teaching basic skills, and encouraging students to apply their skills within many rich problem solving contexts. Basic concepts, computation skills and applications are interwoven at every level, so all students are involved in both mastering and applying concepts in diverse situations.

This comprehensive curriculum has a core of five goals:

- Emphasize mastery of essential concepts and skills
- Promote higher–order thinking skills
- Build positive attitudes toward mathematics and learning
- Feature content well–suited to technology
- Cultivate independent work habits and on–task behavior

Middle school mathematics focuses on students thinking logically, forming valid opinions and inferences, and developing curiosity and appreciation for mathematics.

Content

One hundred 15–minute lessons at the sixth grade level form an extension of the Josten Elementary Mathematics Curriculum. The seventh and eighth grade curriculum is comprised of eighty 40–minute lessons which extend the concepts and skills developed in the elementary curriculum. The lessons, reviews, and tests are organized into four strands. There are four units in each strand and five lessons in each unit.

Each seventh– and eighth–grade unit is self–contained and includes provisions for prerequisite skills and ongoing and summative evaluation. Teachers may sequence the curriculum in a spiral development across trends or provide focused coverage on specific strands.

Students begin each lesson with 'warm–up' experiences. These require mental computation and a review of concepts and skills needed for success in the lesson's main body. The lesson body gives students developmental instruction on pertinent subject matter, followed by experiences focusing on problem solving and application.

Estimation, mental computation, and problem solving skills are integrated into each lesson as key components.

Strands

Number—explores integers, exponents, primes, rationals, irrationals, ratio, proportion, and percent

Algebra—explores variables, linear functions, inequalities, absolute value, and quadratic functions

Geometry/Measurement—explores perimeter, area, volume, lines, angles, planar and spatial figures, symmetries and transformations

Graphing/Statistics/Probability—explores graphs, measures of central tendency, range, deviation, permutations, combinations, sampling, and experimental probability

Lessons engage the students in self–paced learning experiences that collectively introduce, develop, model, and apply specific concepts and skills in a supportive, interesting and user–friendly environment.

Lessons develop concepts and skills through inductive, developmental interaction—not drill/practice tutorials commonly marketed by software vendors. Students are not taught to 'find the right answers'—they are challenged to make reasonable approximations and discover how their skills can be used in new situations.

Instructional Integrity

The Josten Middle School Mathematics Curriculum reflects the combined efforts of nationally recognized experts. Lessons closely parallel the scope and sequence of major textbooks and address concepts measured by popular standardized tests. The program includes detailed correlation studies with district textbooks and tests as well as with state and/or district objectives.

The Josten Curriculum complements work of the classroom teacher by providing individualized instruction in essential skills. The program provides an equal opportunity for students to build, on their own terms, a math skills foundation on which teachers may overlay enriching learning experiences.

Higher–order Thinking Skills

The Josten Mathematics lessons are not books on a screen. The self– paced, learner–oriented and interactive activities go beyond drill and practice. Specific focus on critical thinking and problem solving helps students take control of learning and see applications beyond the textbook.

Technology Enhancements

Calculated use of state–of–the–art technology makes learning motivational and multi–sensory. Color creates interest through graphics individually designed for each lesson. Color also teaches by highlighting important concepts. Digitized human speech gives directions, teaches vocabulary, ex-

plains important ideas—and gives frequent 'pats on the back.' Students may access on–line calculators in appropriate lessons. Combined mouse and keyboard inputs offer multi–sensory variety and alternatives for interacting with computers.

Instructional Management

The Josten Management System exceeds boundaries of typical record keeping. The host computer monitors each lab session and delivers in less than ten minutes an appropriate lesson for each student. Teachers have the option of inserting a single lesson for an entire class or specific lesson changes for individuals. These modifications can be made on short notice, without cutting into student time on task. The system ends each lab session at the proper time and automatically collects and stores results.

Initial and On–going Testing

The Josten Basic Skills Inventory (BSI) initially places students in the mathematics curriculum and diagnoses appropriate learning paths for individual students. The BSI data permits teachers to group students with similar skill levels.

The Josten Management System provides testing at lesson and unit levels, as well as detailed evaluations of student progress on mathematics content and three levels of mental processing. The strong emphasis on students' abilities to use mental processing skills reflects Josten's commitment to higher–order thinking skills.

The Josten has focused its attention on a few content areas and has tended to limit its work to elementary or, in some cases, middle school curricula. Immediate plans, however, include materials development in life skills and employability skills. These two areas are of immediate interest to vocational educators. A concern is whether instructional objectives and strategies common to vocational education are amenable to Josten design and development efforts in other curriculum areas. Experiments are needed to ascertain whether the Josten learning system could in fact accommodate vocational education curricula.

Support

Implementing an integrated learning system is a major undertaking for any district or school. Too often, districts have purchased hardware and software and fended for themselves in implementing their purchases. Results have been disappointing. Josten acknowledges the importance of support systems for schools using its learning system and has attempted to provide them to clients.

The Josten support and service program helps schools prepare for, install, and operate the integrated learning system as a long–term investment. To that end, Josten provides support as per the following description provided by Josten to their clients:

Outstanding After–Sales Support

Service to a client school is Josten's first commitment. Josten employs a nationwide network of account managers dedicated to ensuring total success of your Josten Lab.

Your account manager is an experienced professional who provides a complete training program and ongoing support for your Josten Lab. The account manager's main objectives are to help establish your lab as an integral part of your school environment and to develop synergistic relationships among lab personnel, faculty, administrators, parents, and the community at large.

Once the Josten Lab is ready, your computer equipment will be installed. Josten will be on the spot to ensure optimum installation. Immediately following hardware installation, Josten Client Support will:

- *Test the system for flawless operation*
- *Load the Josten Curriculum Software and assist with class scheduling*
- *Hire your lab attendant, when appropriate*
- *Train the lab attendant*
- *Conduct teacher inservice training*
- *Supervise student orientation and start–up of classes*

Lab Attendant Training

Your Josten Account Manager completely trains a full–time lab attendant who supervises and maintains lab operations and serves as direct liaison to the classroom. This training is done one–on–one in the Josten Lab and includes thorough instruction on:

- *Hardware*
- *Operation System*
- *Instructional Management System*
- *Software/Curriculum*
- *Lab Attendant Functions*
- *Troubleshooting*
- *Support System*
- *Student Orientation*

Josten provides thorough documentation and support for lab attendants, including the Josten Lab Reference Manual and Quick Reference Card—and supervision by your account manager.

Teacher Training and Inservice

Your staff plays a very important role in the success of your integrated learning system. To help them fully understand the Josten Curriculum and lab operations, your account manager will conduct a training session designed to orient them to the management system, curriculum design, tests and reports—plus hands–on experience with your Josten System. Documentation for teachers, including the Josten Curriculum Guide, is available in your lab.

Student Orientation

Your Josten Account Manager and Lab Attendant work with your teachers to customize a plan for student orientation. This includes visits to the classroom, keyboard color–in chart for lower grades, tutorial lessons on the use of the keyboard, mouse, and calculator, and a plan for gradually starting up your class schedule in your lab.

Ongoing Support

Throughout the year, your Josten account manager supervises your onsite lab attendant,

provides continuous training and support, and generally works to fulfill the needs in your Josten Lab.

Consulting and Evaluations

To improve Josten service on a continuing basis, Josten's staff of educational consultants works with your account manager and school staff, addressing educational needs particular to your school and district. Your account manager also collects evaluations and feedback from students, faculty, and administrators. This information can be coupled with data from district testing for a comprehensive effectiveness study. Josten educational consultants help your district evaluation staff design an extended evaluation plan that will also be used to help improve all aspects of the Josten System.

District and Community Relations

During regular site visits, your account manager also provides additional services that go beyond the Josten Lab. He or she meets regularly with teachers and administrators, either as a group or individually. Your account manager helps you coordinate activities to increase community awareness and involvement. These include:

- *Planning and hosting of open houses for parents and/or district personnel*
- *Arranging news coverage from your local newspapers and television stations*
- *Arranging activities and events to raise the level of awareness and support in your community*

Troubleshooting

Your Josten Lab Attendant is trained to troubleshoot, diagnose, and handle any possible hardware or software situations arising in your lab. If he or she needs help or advice, the Josten Technical Hotline is only a phone call away. Our response time is always immediate.

Your account manager is also available for assistance whenever needed.

It remains to be determined if Josten provides the levels of support suggested in its literature. Support systems are vital to schools realizing full benefits from investments in integrated learning systems. Vocational educators who explore the use of integrated learning systems must establish the kinds of support needed from the vendor. These needs encompass the beginning of a school's use of the system, and, perhaps more importantly, the entire life of the system.

Does the Josten Learning System Work?

Vocational educators wishing to use the Josten learning system in their schools must ask a bottom–line question: Does the system work? At the most basic level, asking this question involves asking at least three related questions: 1) Is the content in a Josten curriculum appropriate and relevant? 2) Do students learn the material in the curriculum? 3) Do students and teachers like to use the system?

At the time of this writing, Josten has installed and has operating laboratories in about 900 schools (some of whom have more than one laboratory), in almost all states plus the District of Columbia. Preliminary answers to the "Does the system work?" questions posed above may be construed from the performance of Josten products over the past three years. Based on data supplied to the authors by Josten , some responses can be made to the questions.

Content

Judgment regarding content relevance of a Josten curriculum is a primary consideration for school districts considering procurement of a learning system. When a district buys a system it reflects judgment by the district that the content is appropriate, as the content of a Josten learning system is central to the whole concept of the system. The cost of an integrated learning system restricts districts from purchasing it without thoroughly examining the content of the system's curriculum.

Relevance of a learning system curriculum may also be measured by the extent to which the curriculum meets mandated or suggested curriculum requirements. The extent to which the curriculum prepares students for standardized achievement tests may also be viewed as a measure of curriculum

relevance. An example: in attempting to assess its curriculum in reading and mathematics, Josten conducted studies to determine the alignment of Josten reading and mathematics curricula with objectives from the California Achievement Test (CAT). Findings from these studies are as follows:

> *The Josten Reading curriculum provides instruction for 84% (32/38) of the CAT objectives included in the categories of Word Analysis, Vocabulary, Comprehension, and Study Skills. Further analysis revealed that 5 of the 6 objectives not covered by the Josten curricula rely heavily on oral instruction.*
>
> *The mathematics comparison included all 20 CAT objectives in the two mathematics categories, Mathematics Computation and Mathematics Concepts and Applications. Coverage by Josten was complete: 100% of the CAT mathematics objectives are addressed by the Josten mathematics program.*

This one test of curriculum relevance provided positive results for the Josten learning system. Vocational educators interested in curricula at the secondary level might well ask "It is possible for appropriate curricula a Josten system to be developed in vocational education areas, and what would it take to develop such curricula?" Job–specific vocational education curricula are probably in the distant future for Josten. However, generalizable skills that transcend several vocational education disciplines may be quite feasible in the near future for the Josten learning system.

Learning outcomes

The second question, "Does the system work?" focuses on learning outcomes. That is, do students learn what they are supposed to learn from the system? Once again, there are no data directly relevant to learning outcomes in vocational education subjects at the secondary level. However, data may be examined for learning outcomes in existing curricular areas.

The authors reviewed reports describing student achievement in three elementary schools containing Josten learning systems. Two of the schools are in California and one is in the State of Washington. The reports contained considerable data on achievement for each school. Studies conducted depict the character of each school and the respective student achievement results obtained with the Josten system. Following are narratives providing study summaries. All three studies occurred during the 1986–87 school year.

Evaluators emphasized that for each of the three studies the Josten laboratories were but one factor (albeit, from Josten's perspective, a primary factor) in explaining achievement gains. One must thus interpret achievement data with caution. The data suggest that Josten learning systems made a very positive impact on achievement in the schools studied. The extent to which these positive outcomes are likely to occur in secondary curriculum areas in general, or in vocational education curricular areas in particular, is unknown. However, if one assumes the same care given by Josten to the design and development of instructional programs at the secondary level that seems to have occurred at the elementary level in reading and mathematics, there is reason to be optimistic that the learning system could enhance student learning in vocational education curricula.

Aside from a few anecdotal remarks attributed to teachers or administrators currently using Josten learning systems, the authors did not obtain systematically gathered data that documents student and teacher reactions to the learning systems. One is tempted to infer that students and teachers must be motivated to use the system. However, this remains an inference until other kinds of data on this topic are made available.

Does the learning system work? Based on current evidence, the answer must be yes, in those areas and at the levels in which Josten has developed programs. Intuitively, the system ought to work: Curricula have been carefully selected with advice from prominent subject matter specialists; content has been aligned with testing measures and other forms of curriculum mandates; instructional strategies have been carefully designed according to extant theories of teaching and learning; attention has been given to student motivational factors; materials have been pilot tested and evaluated; hardware and software systems have been selected and designed to be user–friendly; instructional management systems have been carefully built into

School #1

School #1 is one of 30 district schools designated as a magnet school as part of a large city school district voluntary integration plan. The school opened with a new magnet program in 1986–1987 that was developed to implement the nationally acclaimed International Baccalaureate/College Preparatory Curriculum. This magnet program emphasizes basic academic skills with additional focus on mathematics, computer education, writing, study, and social skills.

The school's enrollment is 730 students. The racial and ethnic representation includes 55.1% Hispanic, 38.7% Black, 3.2% White, and 3.0% Asian. The enrollment has steadily increased during the past five years and has a mobility index of approximately 70%. The school conducts may special programs to strengthen the academic program. These programs serve special needs students and include a Chapter 1 program, a state school improvement program, a basic skills assistance program, a district achievement improvement curriculum, and an attendance improvement project.

The district installed a 30 student station Josten computer learning center to increase support of objectives of the International Baccalaureate Program. All students (grades 1 to 6) were scheduled for two 30-minute computer lab sessions to receive Josten lessons in reading and mathematics. Kindergarten classes began the second semester of the year.

The district has administered the Comprehensive Tests of Basic Skills (CTBS) since 1980 to evaluate student achievement and to assess the effectiveness of basic skills instructional programs. Special measures by School #1 permitted initial evaluations of the impact of the Josten Learning Center. These measures included developing matched student CTBS score data, conducting teacher interviews, and analyzing student achievement based on the CTBS content objectives and concepts for reading and mathematics.

The CTBS data are for students who were enrolled in School #1 for the full school year. School #1 test results supported the following observations:

1. An indication of the overall level of academic performance in a school can be determined by examining the historical test data over a number of years. Since 1980, the general achievement levels in reading, language, and mathematics as measured by the CTBS have consistently trended upward.

2. To project target achievement scores for 1986–87, a trend line was developed using CTBS reading and mathematics scores for the past seven years. Based on the 1986–87 CTBS test results, the reading scores equaled or exceeded the projected scores across all grade levels.

The mathematics scores exceeded the projected scores for five of the six grades.

3. As noted earlier, School #1 instituted a number of projects to strengthen student achievement including a Josten Learning Center and an attendance improvement program. While these and other efforts will be evaluated by the district during the next several years, the Spring 1987 CTBS data highlighted the following results:

The 1986–87 reading scores exceeded all reading scores for 1985– 86 for Grades 1–6.

The 1986–87 mathematics scores exceeded the mathematics scores for 1985–86 for Grades 1–5.

4. Score trends may also be examined by tracing the results for the same students of several test administrations over successive school years. The CTBS test data were compiled for students who were continuously enrolled at School #1 for 1985–86 (the year the magnet program began) and 1986–87 (the year Josten Learning Center was installed). Matched percentile scores, while portraying mixed amounts of change, indicated consistent upward trends for reading, language, and mathematics with pronounced gains at Grade 6.

School #2

School #2, grades K–5, is located in an upper–middle–class community in California. Students represent families from professional, business, and military socioeconomic levels. Enrollment has steadily increased the past three years. The student population is characterized by low mobility—25% for 1986–87, and the school has a record of high academic performance. School #2 received the California State Department of Education Distinguished School Award for the academic year 1986–87. The recognition resulted from a high academic performance for the previous five years, a strong staff development program, and a desirable learning environment.

School #2 installed a Josten Learning Center in October, 1985. The computer lab was scheduled to provide all students instruction supervised by classroom teachers. Students attended computer lab sessions for three 30–minute sessions each week to receive individualized Josten reading and mathematics lessons.

The Comprehensive Tests of Basic Skills (CTBS) was used by School #2 to evaluate student achievement in reading, language, and mathematics. Total reading scores and subtest scores for Word Attack, Vocabulary, and Comprehension for grades 3 and 5 indicated significant achievement gains. While total mathematics scores and subtest scores for Computation and Concepts/Applications for 1985–86 were at exceptionally high achievement levels, the subtest scores showed important gains for both grade levels. for 1986–87.

the system; research and evaluation studies have been conducted; and support systems have been carefully developed and provided for schools buying the system. The results to date are very positive. All of this bodes well for the further migration of the system to the secondary level, and possibly to curriculum renovation in vocational education.

What Does a Josten Learning System Cost?

As is the case with any large–scale instructional technology system, the question of cost must ultimately be addressed. The most attractive and effective learning system in the world will not be implemented unless it is a cost–effective alternative.

Corporations that market learning systems (or other forms of multi– media technology systems) are reluctant to quote precise cost figures for hypothetical situations, as local conditions for a school determine final costs. In addition, costs for both hardware and software continue to fluctuate. In view of these constraints, the authors have attempted to gain a cost estimate for an Josten learning system.

Two hypothetical cases are described. The first case consists of a 12–student workstation laboratory, with reading and mathematics curricula installed on the system. Given this configuration, costs might approximate:

1. Perpetual software license for laboratory with 12 workstations	$37,800
2. Software maintenance agreement (3 years, annual cost $5334)	10,850
3. Hardware	33,000
TOTAL	$81,650

In addition to these costs, a district must consider hardware maintenance costs over the life of the system. These include costs for upgrading the system in response to changing instructional needs.

Districts should plan for annual expenditures of approximately $15,000 for systems and hardware maintenance for this type of system. Initial capital costs are substantial, but annual maintenance costs

School #3

School #3, located in the state of Washington, is one of ten elementary schools in its school district. The school enrolled 550 K–6 students in academic year 1986–87 and its growth rate exceeded 6% for the previous four years. Extensive Navy operations are housed within the school's region which provides technology related employment. Student mobility for the school is over 35%. The ethnicity of the student population is 82% majority and 18% minority.

Instructional Programs: Computer Assisted Instruction

The district initiated its first major technology program at the elementary school level in 1986–87. A Computer Assisted Instruction (CAI) System by Josten was selected by School #3 after extensive review by a committee composed of parents, teachers, and administrators. The selection was based upon carefully defined criteria designed to meet the needs of instruction for district students. The main goal for the placement of a CAI lab at School #3 was to improve student instruction in the basic areas of math and reading.

Josten Computer Lab

A 32 work station computer lab was installed and in use by School #3 students on the first day of the 1986-87 school year. Students in grades 1– 6 were scheduled for computer lab sessions for 25 minutes for reading and mathematics instruction every other day. In February, 1987, the program was introduced to 14 kindergarten students.

Staff development activities began in August, 1986, with presenters discussing the Josten curriculum, students' scheduling, and lab management. The Josten curriculum documentation was a topic for a training session that stressed integrating classroom basic texts and computer lab lessons. Teachers accompanied their students to the lab for each session. This permitted them to monitor student work while becoming familiar with the Josten curriculum. The lab involvement allowed teachers to master the Josten program for maximum instructional effectiveness.

Student Achievement Results

An evaluation plan for the Josten computer–assisted instruction program at School #3 was based on two goals for 1986–87:

1. A five (5) percentile point average gain in student learning in the basic skills of reading and mathematics in the grades 1–6 program.
2. Student progress at their own rate in learning reading and mathematics basic skills.

Data for the first goal were based on the pre–post results of the Metropolitan Achievement Test (MAT). The test was administered at grades 2, 4, and 6 in October, 1986, and April, 1987. The MAT consists of nine tests in five domains—reading, mathematics, language, science, and social studies. Only the results for reading and mathematics were included in this evaluation. Although test data reflected the combined effects of all the school's instructional teaching strategies, the Josten computer lab program was the one new component which provided systematic, individualized instruction in reading and mathematics for all students.

Reading. Comparing the fall and spring MAT reading scores for grades 2, 4, and 6, gains ranging from 5 to 16 percentile points occurred in Vocabulary, Word Recognition, and Reading Comprehension for all grade levels except for Vocabulary, Grade 6. Total reading scores improved at all grade levels. Reading Comprehension, the goal of reading instruction, had the best overall achievement gain.

Mathematics. Mathematics tests were given in the three areas of Computation, Problem Solving, and Concepts. Test results showed gains of 5 to 16 percentile points at each grade level except grade 2 where no change occurred in the Computation test score. Total mathematics scores showed important gains at grades 2, 4, and 6.

The Problem Solving Test evaluates student performance in the application of the four basic mathematical operations in verbally stated problems. This is a major goal of School #3 mathematics instruction and one of the principal strands of the Josten mathematics curriculum at every grade level. Problem Solving Test results showed significant gains in this skill for each of the three grade levels.

Summary

The pre–post MAT scores for School #3 Total Reading and Total Mathematics scores support the following conclusions:

1. Grade 2 students gained 13 percentile points in reading and 8 percentile points in mathematics.
2. Grade 4 students gained 11 percentile points in reading and 9 percentile points in mathematics.
3. Grade 6 students gained 4 percentile points in reading and 10 percentile points in mathematics.

This comparison of pre–post achievement scores at grades 2, 4, and 6 indicates the school goal of a five percentile point gain for reading and mathematics was overwhelmingly met with the exception of the grade 6 reading where the total score rose from the 68th percentile to the 72th percentile.

MAT Performance Indicators

The MAT Content Cluster Summaries use three performance categories—Low, Average, and High—to reflect grade level performance patterns of students. These indicators compare student performance for a school in relation to the performance of a nationwide sample of students tested at the same grade level on a MAT content cluster, such as Reading Comprehension. To interpret the three categories, they are defined as: Average—the middle 54% of the norm group; Low—the lowest 23%; High—the highest 23%.

Using these three performance categories, pre–post test results for Reading Comprehension, Mathematics Concepts, Problem Solving, and Computation, in Grades 2, 4, and 6, suggest that with the exception of Computation, Grade 2, the percentage of students in the High performance category was significantly above the norm percentage of 23%. Increases ranged from 8 to 22 percentage points.

From these data it can be concluded that Reading Comprehension, Mathematics Concepts, and Problem Solving achieved outstanding gains for 1986–87. These three areas represent the development of higher order thinking skills which is of special importance in assessing the classroom instructional program and the Josten Learning Center.

are considerably less. In addition, Jostens may offer discounts on these prices, depending on local conditions and negotiations.

Additional costs must be considered if a district purchases and uses a learning system. Space, for example, must be provided for the laboratory. Security measures should be installed for the laboratory space. Training costs are also important expenditures.

Any technology system has both obvious and less–obvious costs associated with the system. School districts must carefully plan for technology implementation, or the system may prove ineffective simply because insufficient support was provided for the system to achieve desired goals.

Module 2

Setting: Selected classrooms and resource centers, wherever appropriate to provide student access to the technology system.

Description: Student workstation.

Purpose: Provide access for students to information resources and instructional activities as part of classroom programs (CAI, CBI, CMI, drill and practice, simulation, applications, productivity tools, tutorial, video, communications, printers, etc.).

Components:

1. Microcomputer connected to a high speed local area network.
2. Color video display with graphics, text, and television capabilities connected to local shared video network.
3. Network resources; storage, communications, and output devices.
4. Alternative input devices (mouse, digitizing pad, touch screen, etc.)
5. Audio headset for video network.

Special Features/Requirements:

Since the application of this station will take on many roles in different instructional settings, specific hardware configurations will vary. However, primary functions will remain intact by providing access to learning systems, enrichment activities, information resources, and communications. The work station will encourage appropriate monitoring of student progress, participation, and assignment of activities.

Chapter 4

Developing and Implementing a Large Scale Integrated Technology System: Sacramento's Perspective on the Future

Introduction

Suppose your access to instructional technologies was not limited to just an overhead projector, or a single microcomputer, or a videotape recorder. Imagine access to a full range of technologies, all which were integrated and available to you, the teacher, or to any or all of your students. Suppose you had access to a wide range of information resources on virtually every aspect of the topics you were trying to teach. And further, imagine you could plan your lessons from home by using technology linked to this instructional classroom. What is your image of this fantasy classroom? Can you imagine the level of learning that could be achieved by your students?

A dream? A fantasy? Many educators have tried to imagine a time when they would have access to a wide range of technologies. These teachers have felt frustrated in trying to do their jobs with limited information and very few instructional tools. Many of us have wished for the day when we could call up television or computer programming, or a range of other instructional resources that could help us deliver instructional messages. We have dreamed of the day when students could pursue programs tailored to their needs of great interest to them. Technologists, of course, have long envisioned the promise for such an exciting instructional environment. Advocates of technology have repeatedly proclaimed that technologies are the answer to making learning interesting, stimulating, and effective.

One school system has set out to make instructional technology claims a reality. While many districts are experimenting with technology, the Sacramento City Unified School District has taken major steps to implement a technology plan for the 21st century. Sacramento, California, houses a project known as the Model Technology Schools. This project, funded by the State Department of Education in California, is one of five model technology school efforts supported in that state. The model technology school project provides interesting insight into a 'total' information technology system for use in

schools. This chapter is devoted to a description of the Sacramento City Model Technology School (SCMTS) project.

Some readers may be inclined to stop reading right now, and to say that whatever is going on in Sacramento has no relevance to their own district because the costs involved in establishing a complete integrated information technology system far exceed what is available in most individual districts. Those readers are urged to continue. The Sacramento Model Technology School project does not need to be replicated at Illinois sites exactly as it is being done in Sacramento. However, the idea of an integrated information technology system is worth consideration by education for employment systems in Illinois. The Sacramento project represents a strong possibility for successful applications of technologies in the future. Costs are a factor, but the reader is urged to consider the concept before making judgments about feasibility.

The Sacramento Context

In studying the technology system encompassed within the SCMTS, the reader must consider the context within which that SCMTS is being placed. This section briefly describes the Sacramento area.

Sacramento is the seventh–fastest growing metropolitan area in the nation. In many respects, the city represents a microcosm of the future of urban America through its increasingly multi–ethnic population. Projections for the year 2000 indicate a population of approximately 415,000 residents for the city proper of Sacramento and 1,200,000 residents for the greater Sacramento area.

The Sacramento City Unified School District is a large urban school district serving over 50,000 students and 75 schools and centers. A recent environmental impact study indicates that the school district must brace itself for a potential doubling of student population in the next 25 years. Currently, the district has geographic boundaries which encompass an attendance area of approximately 67 square miles. Within this area exists a broad variety of neighborhoods and socioeconomic levels, ranging from severe poverty to considerable affluence.

As overall enrollment in the Sacramento City Unified School District has increased steadily since 1980, the percentage of racial/ethnic minority students, as well as the percentage of students characterized as socially disadvantaged, has also increased. The district currently has a minority enrollment of 60%. In addition, 40% of all K–12 students come from families receiving Aid to Families of Dependent Children. At least 50% of the children in the schools included in the Model Technology Schools project come from families receiving AFDC. The minority enrollment across the three model technology schools is 75%. The transiency (student turn–over) rate for elementary schools in the district as a whole is about 80%, and for secondary schools, about 60%. In the model technology schools, the rates of transiency are 90% for the elementary school and 79% for the secondary schools.

Academic performance of students in the Sacramento City Unified School District, as measured on standardized tests, tends to be lower than the average performance of students across the state of California, but somewhat more favorable when compared to students in other urban districts in the state.

In summation, Sacramento provides a dynamic urban environment for the development and testing of technology applications in education. The district contains a rich variety of racial, ethnic, and socioeconomic backgrounds among its students and thus can be an important test for the ways in which technologies might have impacts and on whom. The district also offers an environment where clear commitments have been made to explore the potentials of technologies for improving the quality of educational opportunities in Sacramento. This interest in and commitment to technology applications may be viewed most dramatically in the hiring of a new superintendent, an individual who has a history of commitment to technology applications. Furthermore, the district has already begun to pursue its technology agenda by creating in one of the district schools a technology training center, a facility that contains an array of information technologies. This facility is used to train teachers, administrators, and other individuals to explore the potentials of new technologies for improving education in the school district. It is important to understand these commitments to technology, for without such commitments, it is unlikely that the Model Technology Schools project could have been launched in Sacramento.

In some ways, then, Sacramento is representative of many of the urban areas in the United States. The particular environment of Sacramento may be quite different from the environment in a small rural community or even a smaller urban population. It is clear, however, that the Sacramento City Unified School District must try to meet the unique learning needs of a wide range of kinds of children and adults in the community. The integrated information technology system used in Sacramento must, above all else, be able to address the learning needs of such a diverse population. Anyone looking at the Sacramento experiment will undoubtedly be able to find representatives of the kinds of students he/she must serve in his/her own community. Therefore, while Sacramento may not be representative of all areas that may wish to utilize integrated information technology systems, the example of Sacramento is a useful one to study.

The Conceptual Foundation for the Sacramento MTS Project

The Sacramento City Model Technology Schools project is a project of major proportions. In an effort to help the reader of this *Notebook* grasp the significance of the size and complexity of the undertaking, we present in this section a rather lengthy overview of the goals, philosophy, intended learner outcomes, instructional/learning strategies, and instructional support strategies that undergird the SCMTS project. We describe these matters because without this background, the reader might be tempted to view the Sacramento project as simply the collection of a lot of hardware. The technology system as a hardware and software system, important as it is, represents only part of this case study. Vocational educators interested in the integrated information technology system in Sacramento need to be aware that the system includes in its design perspectives on teaching and learning that dictate to a considerable extent the use of the system.

With that brief caution, on to a discussion of the foundations of the SCMTS:

In 1987, the state of California announced its intention to support a limited number of model technology schools. The intent of this effort was to provide focused arenas within which technology applications could be tried and evaluated. A competition was held, open to all school districts in the state of California. The competition resulted in a number of proposals being submitted. Five projects were ultimately selected to become model technology schools. Sacramento City Unified School District was one of those five districts.

The model technology schools project in Sacramento was slated to begin in the fall of 1987. By the time administrative arrangements were concluded, the project actually began operation in November, 1987.

The Sacramento MTS involves one elementary, one middle, and one high school in the Sacramento City Unified School District. Teams of teachers and administrators were selected to work on the model technology schools project in these three schools. The schools are supported heavily by the central administration. The MTS projects are scheduled to be implemented for a period of five years, funded by the state at approximately $500,000 a year.

Goals of the MTS Project

In its proposal to the state, Sacramento identified nine primary goals for the MTS program. These goals, while very specific to the Sacramento project, can be viewed as applicable in other instructional settings. The goals, together with a brief explanation of each, are as follows:

The SCMTS will attempt during the course of the project to:

> *1. Improve student academic performance across curricular areas by facilitating student acquisition and application of communications and critical thinking/reasoning skills.*

Through the use of technology, the SCMTS will strive to improve the teaching and learning of a variety of communications and critical thinking skills. These skills are fundamental to academic performance in most academic or curricular areas, and are currently not being learned as well as desired.

> *2. Improve certain behavior or attitudinal patterns that can negatively affect academic performance (e.g., excessive absenteeism, dropping out, poor self–esteem).*

While not exclusive to large urban school systems, negative behavioral and attitudinal patterns exhibited by many students in urban settings hinder their ability to perform academically. It is the goal of the SCMTS to utilize technologies to encourage higher levels of student motivation, success, and interest in learning, thus increasing self–esteem and reducing incidents of absenteeism, drop–out, etc. The intent, in part, is to change the social and intellectual climate of the schools through the uses of technologies.

3. Restructure school organization, policies, and procedures in ways that will permit more flexibility in the ways instruction is delivered to students, encourage more customized and collaborative learning activities, and, in general, support alternative patterns of teachers and administrators working together to provide quality educational experiences for students through the appropriate applications of technologies.

Traditional patterns of school organization and practice do not always encourage or even permit the potential contributions of technologies to be realized. The Sacramento MTS is committed to exploring alternative organizational and policy arrangements that will facilitate a true test of the capabilities of technologies to contribute positively to the kinds of learner outcomes desired.

4. Prepare staff, students, business partners, parents, and other significant individuals to utilize technologies, and to continue to support staff and others through planned programs of continuing education, technical assistance, and the establishment of electronic networks based on common interests or responsibilities.

This goal reflects the intention of SCMTS to adequately prepare its staff and significant others to permit them to take advantage of available technology options. Further, initial training by itself is not sufficient; teachers and others who work with technology need a source of ongoing support and assistance.

5. Develop exemplary instructional packages, units, and materials that are evaluated and revised as necessary, and that can be disseminated to other schools or educators throughout the state.

Those involved in the SCMTS will experiment with a number of ways of using technology for instructional and administrative purposes. Those experiments will foster exemplary instructional practices and/or materials. Materials resulting from this work will be made available to interested educators.

6. Develop and pursue a research and evaluation agenda designed to analyze/assess the effects of technology–based instructional and administrative practices on both short– and long–term learner academic performance and behavior/attitude patterns, and to disseminate the results of these research and evaluation studies.

SCMTS will develop an ongoing program of research and evaluation studies, aimed at expanding the knowledge base about technology, teaching, and learning. Some of these studies will be longitudinal in nature, some ad hoc. Some will be conducted in conjunction with other MTS sites, while other studies will be done in the Sacramento MTS context alone.

7. Based on the results of the research and evaluation studies pursued in the project, identify policy issues or questions that must be addressed concerning the uses of technologies in schools, and begin to provide analyses germane to those policy questions for use by decision makers.

Systematic attempts to use a variety of information technologies, in a variety of ways, will engender important policy questions that will need consideration as decisions about future applications of technologies surface. The kinds of research and evaluation studies undertaken as part of the MTS project will shed light on those policy issues, and provide data for responding to critical policy issues.

8. Develop enduring school–business–postsecondary education partnerships that will support attempts to use technologies to accomplish intended learner outcomes, and that will foster community understanding of and support for public school efforts.

The Sacramento MTS intends to seek creative partnerships with a variety of business, postsecondary education, and community groups that can

provide expertise, finances, equipment, or other forms of support for using technologies in schools. SCMTS will draw on its rich history of partnerships in Sacramento to support the MTS but will also aggressively pursue the formation of new kinds of partnerships that might be especially effective in supporting their goals and activities. In addition, careful attention to documentation of these partnerships will occur, to share results with other interested education institutions, businesses, or community groups.

9. Develop, in conjunction with local social service agencies, creative ways in which the technologies in the school might also be used to provide more effective, coordinated access by parents to the range of social services available to them.

The impact of the home environment on student academic performance cannot be overlooked. The environment in the home might be improved for students if parents effectively used social services nominally available in the community. Technologies may provide greater access for parents to these social services and thus encourage more parental involvement in and with the school. This enhanced relationship might create a more positive climate for academic performance in the home.

Goals for the Model Technology Schools project are ambitious, reflecting the comprehensive nature of the proposed integrated technology system. Vocational educators considering this system should recognize the importance of the comprehensive nature of the goals for achieving successful learning outcomes in any content area, including vocational education areas and topics.

Philosophy of MTS

The goals stated for the MTS are based on a philosophy toward technology applications held by Sacramento City Unified School District. It is important to understand some of this philosophy, for the philosophy not only dictates goals but also guides the selection of instructional strategies for use in the MTS.

The primary approach to technology applications in the SCMTS is *learner–centered*. That is, the technology system envisioned for use in the SCMTS is to be used by learners to achieve certain desired learner outcomes. The fundamental interest in the project is to understand how learners can and do utilize technologies to pursue learning goals, the extent to which learners are successful in achieving established goals or intended outcomes, and the short– and long–range consequences of involving technologies in the instructional program of the schools. One of the assumptions underlying this approach, of course, is that learners in the SCMTS will be actively and regularly involved in using technologies as part of their learning experience. A second assumption underlying this approach is that the technologies in question will be easily accessible to and usable by learners and those who help learners.

The primary technology uses in the SCMTS will be learner–centered and learner–involved. However, significant learning outcomes from technological interventions are shaped not only by the learner's effective uses of the technologies, but by the supportive and facilitative functions and activities that surround the student's involvement with the technology system. A cause of failure in previous technology applications has been inadequate attention to building and maintaining instructional support activities. Such support is needed over the long term to sustain effective student use of technologies and, in turn, accomplish desired learning outcomes.

Therefore, the SCMTS intends to develop and implement a range of instructional support activities, including training programs, information resources acquisition, development of partnerships between the schools and businesses, etc., that will facilitate instructional activities that comprise the focus of the project.

Two other important aspects of the SCMTS approach bear explication. First, technologies used in the SCMTS must be viewed as tools designed to accomplish certain desired outcomes, and not as ends in themselves. That is, the intent of the SCMTS is not to teach students technology (except in those instances where technologies are the subject of academic investigation, such as studying the history of technology, or examining the impacts of technology on modern life), but rather to teach them how to use technologies to pursue learning objectives.

Consistent with this view of technology use, the SCMTS will not teach courses (or units) in computer

McCorduck and Russell (1986–87), reviewing a study commissioned by the Carnegie Corporation and conducted by Dr. Marc Tucker, spoke to the issue of technology as tools:

More unsettling, Tucker discovered that computers were being used mainly for drill and practice in the basic skills—something that could often be done just as well with paper and pencil and much more effectively with peer-group tutoring. The other principal use of computers was in courses in 'computer literacy.' Says Tucker, "Schools have been conceived of as places that offer courses in subject areas. Accordingly, schools began to develop courses in the workings of the computer and in the rudiments of programming."

Yet, as Tucker points out, neither of these applications permits students to use the computer the way a manager, a writer, a physician, or a composer would. Such professionals generally have little or no interest in how the machine works, and they do not get involved in the design of programming. Their goals are to achieve professional results—a quarterly projection, a novel, a diagnosis, a sonata—as quickly and effectively as possible. For them, the computer is a means, not an end. It is a powerful intellectual assistant that can do the dogwork, suggest alternatives, attend to possibilities that might be overlooked, remember and rearrange ideas, replace guesswork with precision, and finally, free the intellect to make new leaps to unknown places (p. 2).

From: McCorduck, P. and Russell, A. (1986–87). Computers in the schools. *The Key Reporter*, pp. 2–5

literacy, as that term may convey a narrow definition. The SCMTS will rather teach students how to use computers and other components of the technology system to gain information or engage in learning activities designed to teach particular content or skills.

One of the measures of success in the SCMTS will be that the technology itself will, over time, become largely transparent to teacher and learner, so that use

In Tucker's view, real computer literacy would signify mastery over a powerful tool of intellectual and creative endeavor. A pencil is such a tool. But computer literacy courses have become tantamount to 'courses in the pencil': The structure of the pencil, how to sharpen pencil points, the history and social impact of the pencil. "While this might be interesting, what children need is pencils to help them achieve something else" (p. 5).

From: McCorduck, P. and Russell, A. (1986–87). Computers in the schools. *The Key Reporter*, pp. 2–5

of the technology will be as natural and as comfortable as the use of a telephone, electricity, or, perhaps, a pencil. Technology as tools is a vital aspect of the approach to technology envisioned in the SCMTS. Critical to this view in an operational sense, is for the technology to be accessible when needed, where it is needed, and to be usable by all.

The second important aspect of the SCMTS is that any educational program or educational intervention, should be based on assumptions about the nature of the present and future society in which the consumers of the products of education, namely,

In the coming age, technologies will increasingly be tools which all of us will use, as McCorduck (1985) observed:

We think of tools as something for the shed or as implements hauled in by an artisan to fix leaky pipes, bad wiring. But by now it must be clear that workers in the realm of the mind have tools too, whole technologies, if you will that serve the same purpose as any artisan's: they make work more effective, exciting, pleasant, and precise. They are the winches and pulleys, the miter boxes and wheels that amplify our powers in every direction (p. 30).

From: McCorduck, P. (1985). *The universal machine: Confessions of a technological optimist*. New York: McGraw-Hill Publishing Co.

learners, will live. Our society is and will be in the future characterized by the centrality of information and communication. People hold different views as to the everyday implications of living in such a society. Some writers, such as Harlan Cleveland, argue that potential changes and opportunities are profound.

Underlying the technology philosophy of SCMTS is the importance of creating within the schools and the community, a culture for utilizing manipulating, and sharing information and knowledge. The use of the tools to accomplish these tasks must become commonplace within this culture. The SCMTS must help students, teachers, parents, and others feel comfortable with technologies, information, and communications. The fears and phobias that plague many people when confronted with technologies must be sharply reduced if those people are to function effectively in a society where technologies are dominant. The schools can become places for making people feel at home with ideas and technologies.

> The fusion of computers and telecommunications and the developments in biotechnology are the basis for a legion of new activites, new things to do, new "jobs" on earth and in the oceans and in the atomosphere and outer space. The numbers and quality of jobs will be a function not of physical constraints but of the human imagination. Will we use our imagination to create full and fulfilling employment or, at the other extreme, to blow up the human experiment when it has hardly begun? We are back to Barbara War: "We do not know. We have the duty to hope."
>
> But to two predictions I would assign a high probability value. People who do not educate themselves, and keep re-educating themselves, to participate in the new knowledge environment will be the peasants of the information society. And societies that do not give all their people a chance at a relevant education, and also periodic opportunities to tune up their knowledge and their insights, will be left in the jetstream of history by those that do (p. 190).
>
> From: Cleveland, H. (1985). *The knowledge executive: Leadership in an information age.* New York: Truman Talley Books/ E.P. Dutton.

Intended Learner Outcomes

Within this philosophy of technology, and given the broad goals of the project outlined in the preceding section, specific learner outcomes were identified in the SCMTS proposal. These outcomes, although specific to the Sacramento project, are consistent with intended learner outcomes in many educational settings including vocational education programs. Intended learner outcomes of the SCMTS are as follows:

1. Improvement in the academic performance of learners as measured in the various curriculum/content areas.

Over the long term, if information technologies are adopted in widespread fashion by schools, the technology systems must contribute to improved academic performance of students. Learner outcomes are invariably a result of many complicated factors. It is difficult, if not unwise, to relate in a causal fashion any specific outcome to a single variable or treatment. The expense and effort involved in introducing substantial technologies into instructional programs in schools, however, require that those systems, by whatever means they use, contribute to improvements in learning outcomes. Personnel in the SCMTS are aware of the complexities of this issue, but believe improved academic performance across the curriculum is a reasonable goal for and a logical expectation of the technology applications planned for the SCMTS. The goal of improved academic performance will not be realized instantly nor will it occur evenly across the discipline areas represented in the three schools. Investment in educational technologies must be viewed as a long-range proposition. Nonetheless, shorter term gains should be ascertainable during the course of the project.

2. Positive changes in certain learner behavioral and attitudinal patterns (such as low self-esteem, absenteeism, dropping out of school prematurely, etc.) that tend to negatively influence academic

performance.

Educators in the Sacramento City Unified School District are concerned about behavior and attitude patterns of young people, patterns that make it difficult for students to achieve at acceptable levels. One of the goals of the SCMTS is to utilize technologies in ways that permit and encourage individual students to develop higher levels of competence and thus improve their feelings of esteem and self–worth. Low self–esteem reduces motivation to learn or participate in educational activities and tends to eventually lead to other behavioral patterns that exacerbate problems of poor academic achievement.

Technologies hold promise for providing types of learning opportunities that young people find interesting, even stimulating. Technologies may help young people succeed more often, and when those young learners do fail at a task, the technology may provide a manageable means of remediation without embarrassing the learner. Sensitivity to the personal and social development of the individual student is critical to improving academic performance.

3. Improvement in the abilities and inclinations of students to form and work in collaborative and supportive learning environments that provide the social and intellectual support systems needed by learners to succeed academically.

Certain learners, particularly minority students, often lack the kinds of support groups or systems they need to perform academically. These intellectual and social support groups, by whatever name they are called and by whatever form they assume, appear to be important in achievement patterns of learners. The absence of support groups for individual students in many urban schools may hinder their achievement.

There are a variety of ways necessary support groups and systems for learners may be encouraged. Cooperative learning projects, for example, represent one approach. The SCMTS intends to explore ways in which technologies may assist learners to create support groups and, once in a support network, exercise those skills needed to effectively use them.

These, then, are the kinds of significant learner outcomes sought through the SCMTS project. These intended outcomes form the conceptual and operational structure within which instructional and instructional support strategies for achieving those outcomes have been developed, and from which, in turn, project activities were defined. Strategies related to instruction, to be employed in the SCMTS project are introduced next.

Instructional/Learning Strategies

The instructional/learning strategies used in the SCMTS project (teaching and learning strategies in which students engage for purposes of acquiring and applying communications and critical thinking skills across curricular areas) must reflect both the content or substantive focus of the project, and the instructional capabilities of select technologies. The SCMTS proposes the following guidelines in designing its instructional activities:

1. Increase the amount and kinds of individualized or customized learning opportunities and experiences available to students.

In recognition of the capacities of some of the emerging information technologies and in view of the desire to more fully engage each learner in the instructional process, the SCMTS is committed to greatly increasing the proportion of customized school experiences for each learner. Individualized instruction has been a lofty goal in education but has seldom been achieved. Barriers to individualizing instruction include the instructional management problems associated with trying to tailor educational programs to individuals. New technologies, however, hold promise for enabling both learners and teachers to achieve higher levels of customized instruction. SCMTS proposes to test those promises.

2. Provide more highly motivating, information–rich instructional opportunities for students.

A major roadblock to providing quality education has been lack of access to a rich base of information resources which may be accessed by both teachers and learners. Students are often limited to only a few textbooks, and library resources may be poor. For schools with some computer or video capability, software programs are often few and dated. Most schools cannot keep up with the costs involved in purchasing information resources. As a result, instructional strategies in many schools must be

planned within the often severe restrictions imposed by available information resources.

New information technologies have potential for bringing to the school, classroom, and individual learner a vast array of information resources, including resources heretofore unavailable in any form to schools. Furthermore, these new technologies permit the updating of information resources more easily and enable teachers and learners to benefit from resources that are current. Society is growing increasingly dependent on information resources. Citizens for our future will need to effectively cope with a broad range of information resources and products. SCMTS plans to explore technologies that may greatly increase the richness of information resources available to learners, an intention that is necessary for increasing individualized instruction.

3. Provide greater flexibility in the ways in which learners and teachers spend their time during the day.

If learners are to engage in expanded forms of individualized education as well as collaborative learning projects, schools will need to be flexibly organized. SCMTS intends to explore alternative ways of structuring the learning environment, including different ways of organizing the way time is spent by learners and teachers. SCMTS recognizes that instructional innovations using technologies may not be possible if those innovations must operate within current organizational and policy structures. The need for flexibility in scheduling to support new instructional approaches is a current priority for SCMTS.

4. Provide more effective and pervasive learner support groups and activities to facilitate the academic performance of individual students.

As previously stated, learners need intellectual and social support groups to assist them in achieving levels of academic performance. The SCMTS plans to carefully and deliberately nurture the development of such support groups in its instructional plans. SCMTS intends to implement both individualized and collaborative learning approaches, believing that for many kinds of learning objectives, an individualized approach is most appropriate and most effective, while for other kinds of objectives a cooperative or collaborative approach is most appropriate. In either approach, however, the intent of the SCMTS is to explore ways in which technologies may enhance instructional strategies.

It should also be noted that irrespective of whether a student is working on an individualized or cooperative learning task, the concept of the instructional support system is important. Individualized education does not mean isolated instruction. In its instructional strategies, the SCMTS will strive to develop appropriate intellectual and social support systems for students.

5. Whenever appropriate, build into instructional activities opportunities for students to utilize the communications options available in the technology system.

It makes a great deal of sense, if one of the objectives of the instructional program is to improve the communications skills of students, to build in requirements and opportunities for students to acquire and practice communication skills. SCMTS is committed to aggressively exploring communications activities that may be embedded in as many instructional units and activities as possible. The capacity of the new information technologies to permit students to communicate electronically with other students, teachers, subject matter experts, and people around the world, as well as for the substance of those communications to be significant and contributory to the student's learning, is awesome and exciting.

Instructional Support Strategies

Strategies for supporting these instructional approaches must be planned and implemented if they are to be successful. The support strategy being followed for the SCMTS is to identify critical areas of the proposed project at which support activities are predicted to be needed and to plan early in the life of the project to put appropriate support activities and mechanisms in place.

Following are types of instructional support activities that will be undertaken as part of the SCMTS project strategy.

1. Training/professional development. Fundamental to the success of the SCMTS will be adequate and ongoing professional development of individuals who will participate in the project.

Teachers are the most vital constituency for training. The number of potential topics for inclusion in

a professional development program for teachers is extensive, including acquainting them with technologies; integrating technologies into ongoing instructional strategies; locating, evaluating, and using a broad array of information resources; using information about learner performance; and working with business and community partners.

Administrators will need professional development to enable them to exercise instructional leadership in a high technology environment that will be essential if the project is to succeed. Support personnel within the schools, such as aides, psychologists, clerical workers, and custodians, will all require some training if the SCMTS is to function effectively. Failure to recognize training needs of any of these groups could prove injurious to the implementation of the project.

In addition to those individuals working directly in the schools, training will be required for several other important groups and individuals. *Parents*, for example, will need to be intimately involved in the instructional program of the SCMTS. In order to be effectively and appropriately involved, parents will be provided with programs and activities of support. This may be particularly important in those instances where technologies are placed in homes as part of the SCMTS instructional program.

School board members occupy a unique position with regard to the SCMTS. If board members are to exercise their responsibilities adequately, they will need periodic briefings on the project. This may include targeted training about technology applications.

The SCMTS intends to develop strong partnerships and relationships with *business and community groups* in the area. Involvement of these partners will depend on the needs of the project at given points and on the expertise and resources of the partner. To make the partnerships really work, SCMTS must recognize the value of various forms of training for its partners.

A compelling training/professional education program is one of the most important instructional support strategies of the project. Planners may not merely conduct initial training activities and then consider the requirements for the training function to be satisfied. Training and professional development will continue for the duration of the SCMTS project.

The SCMTS will explore a variety of ways in which the technology system which teachers and others are being trained to use can itself be employed to deliver continuing professional education.

2. *Information resources acquisition*. The instructional strategies outlined above presuppose existence of a rich array of information resources which are available in the schools to teachers, learners, administrators, and others. An important instructional support activity, therefore, is identification of relevant information resources and the securing of those resources for use in the schools. Numerous information resources reside in schools but not to the extent necessary to achieve instructional outcomes sought in the project.

Issues for bringing information resources into schools include: 1) Teachers will not have time to search for relevant information resources, as their attention must be directed more toward use of information resources; 2) schools need not own information, but rather must have access to the resources as needed; 3) the SCMTS will establish linkages with information resource companies, agencies, and individuals, and will encourage those people to provide relevant information products to the SCMTS; 4) SCMTS will work with other projects funded by the state of California to develop information products.

3. Developing an information management system. Instructional strategies and activities envisioned for the SCMTS require teachers, learners, and administrators to have access to a system that will effectively monitor student performance. Attempts to provide quality individualized instructional programs, for example, are dependent on a means for monitoring the progress of individual students. Each student may be at a different point in his/her learning program. An instructional management system, usable by teachers on a daily basis, will be an essential element of the SCMTS program. Planning, implementing, and maintaining that system on an ongoing basis is a critical instructional support activity of the project.

4. Establishing home–school linkages. Central to the conception of the SCMTS is the idea that student performance may be positively influenced if new kinds of home–school linkages are established and maintained. Parental education may be part of this linkage, but so may new forms of communication between home and school. Technology systems of

the school must be extended to the home. A variety of activities, designed to encourage more productive relationships between home and school environment, will be explored as yet another means of supporting instructional activities.

5. Ongoing curricular analysis. All instructional activities take place within the context of the curriculum of an individual school, the District's curriculum requirements, and state sponsored curricular mandates. An ongoing curricular analysis is underway in conjunction with the planned instructional activities of the SCMTS. These activities will insure that efforts occurring in the project meet requirements imposed on the school. This curricular analysis effort, however, should serve another important function. It is possible, even likely, that one of the outcomes of the efforts in the SCMTS will be the development of ideas for improving existing curricular structures. These ideas should not be lost.

6. Developing and implementing a research and evaluation agenda. Research and development activities are important functions in the Model Technology Schools program. Results of these activities should help guide technology developments throughout the state and the nation. In addition, research and evaluation studies can be of great benefit to the staff of the SCMTS for improving their own instructional efforts. Research and perhaps more so, evaluation, are thus considered primary instructional support activities to be undertaken in the SCMTS.

7. Developing partnerships to support the instructional program. The SCMTS recognizes the potential contributions of partnerships with business and community groups that support instructional activities of the project. The SCMTS approach to building partnerships consists of identifying project needs and seeking partners who can help address those needs. Partnerships will not be limited only to those businesses or agencies that supply technology hardware or software to schools, but to a much broader range of business, higher education, and community companies, institutions, and agencies.

8. Designing, acquiring, installing, and maintaining the technology system. Finally, a critical instructional support activity is implementation of the actual technology system to be used in the SCMTS. Even though the approach taken to technology applications by the SCMTS is that technology is a tool, not an end in itself, that tool must be in place, well-maintained, accessible, and periodically updated. Without a well-designed and maintained technology system, the SCMTS obviously cannot model, evaluate, or demonstrate effective technology applications.

The Technology System

Given the learner outcomes intended in the project and the general technology philosophy supporting those learner outcomes, personnel in the SCMTS have selected an integrated information technology system to provide services in the project. Project personnel examined a combination of computers, video, and telecommunications that may be integrated, capable of moving a variety of information to users and able to make more information available faster than previous technologies used in schools. In designing their technology system, SCMTS personnel decided that the integrated information system should be capable of the following performances:

1. Delivering to classrooms, resource centers, or other locations throughout the schools an array of information resources relevant to the instructional goals of the SCMTS. The system should deliver information resources that are current, varied, dynamic, and of sufficient amounts to permit learning activities envisioned for students in the SCMTS.

2. Permitting extensive individualization or customization of learning activities by enabling individual students to pursue instructional goals at their own pace and with access to information resources especially relevant to the needs and styles of those students.

3. Permitting effective and comprehensive monitoring of student progress and allowing performance feedback to shape instructional practices based on those data.

4. Providing learning experiences that capture the imagination of learners, thus motivating them to work in a sustained fashion to achieve desirable learning outcomes.

5. Being integrated into the ongoing instructional strategies employed by teachers, rather than existing only as an adjunct or addendum to the main processes of teaching and learning.

6. Offering a range of communications options to teachers, learners, administrators, parents, and other

participants in the instructional program of the school.

7. Facilitating the uses of locally developed programs and materials as well as making available products and materials developed elsewhere.

8. Facilitating a variety of collaborative learning projects among learners as well as establishing new forms of instructional support systems.

9. Facilitating of research and evaluation agendas by providing data collection, analysis, and reporting mechanisms that permit effective research and evaluation studies to be conducted within the SCMTS.

10. Providing instructional and instructional support activities in a cost– effective manner.

11. Being ultimately 'user friendly' by teachers and learners who possess minimal technical skills or experience.

The information technology system designed by SCMTS personnel is composed of modules or collections/packages of technologies, each of which has an identifiable function and integrity within the overall design of the system. These modules were to be installed at each of the three MTS schools, generally in a classroom in each of the schools. The classrooms would serve as the SCMTS project, supported by the technology training center previously developed by the Sacramento City Unified School District and physically present at a fourth elementary school in the District.

The SCMTS technology system is a bit complex and therefore somewhat difficult to adequately describe. The best way for the reader to understand the overall nature of the technology system might be to consider some detail on each of the six modules that are included in the Sacramento project. The six modules composing the system include: 1) teacher workstation, 2) student workstations, 3) information resource laboratory, 4) development/authoring workstation, 5) administrative workstation, and 6) home–based technology unit. These modules are networked so that components of each module in the system can interact with all other components of the system. The network is served by an instructional classroom server (a microcomputer) which supports instructional activities in a given classroom, an administrative communication server which supports all administrative functions, and a video network server which supports and controls the flow of video information throughout the system.

What follows is a somewhat abbreviated description of each of the modules including the setting for the module, the purposes of the module, the components of the module, and any special features or requirements that should be considered with respect to that module.

Module 1

Setting: Teacher's desk in individual classroom.

Description: Teacher workstation.

Purposes:

1. Provide curriculum planning and instructional strategies development tools at the desk of the teacher.
2. Provide means of software previewing.
3. Provide means of monitoring student progress.
4. Provide integrated computer, video, and communications capacity with delivery capabilities for large group instruction.
5. Provide means for exercising networking and communications options.
6. Provide avenues for continuing professional education.
7. Provide for the direction and control of video and communications resources.
8. Provide an avenue to carry out required teacher administrative responsibilities.

Components:

1. Microcomputer connected to a high speed local area network.
2. Videodisc and VCR resources.
3. Light table.
4. Color video and computer monitor.
5. Video image delivery system.
6. Network access to remote communications storage and printer services.
7. Shared video network access to Cable ITV or Satellite.
8. Voice communications equipment.
9. Alternative input device, mouse.
10. Monitor/TV large screen display.

Special Features/Requirements:

The system should: provide the teacher with access to the resources of an information society, furnish the means to use the teaching tools of a technology-based system, deliver the means to analyze and report student learning, and supply supporting systems to the instructional program.

Module 3

Setting: Dedicated classroom or instructional space.
Description: Information Resource Laboratory.
Purposes:

1. Provide technology-based setting for large group instructional activities (children, parents, employees).
2. Provide opportunities for large group use of technology workstations for especially assembled groups of learners.
3. Provide means of demonstrating the technology system to groups of visitors.
4. Provide a setting for staff development activities with teachers, administrators, or others.
5. Provide a facility for community or business groups wishing to rent space for training or other functions requiring the uses of technology systems.

Components:

1. 5 student stations (as described).
2. 1 teacher station (as described).
3. Dedicated video (laser disc, VCR, and cable/satellite access) resources.
4. Dedicated remote communications server.
5. Voice communications equipment.

Special Features/Requirements:
This module's implementation will take into account special problems associated with large group presentations: light, seating, scheduling, and flexibility.

Module 4

Setting: Teacher workroom.

Description: Development/authoring workstation.

Purpose: Provide a capacity for teachers to plan/author instructional lessons, monitor student progress, work with other teachers, etc., outside the classroom environment.

Components:

1. Teacher workstation (as described).
2. Local printer.
3. Authoring and application software (word processing, graphics, desktop publishing, slide show, etc.).
4. Manuals and self–learning materials.
5. Local mass storage.

Special Features/Requirements:

The development/authoring workstation will provide an environment rich in preparatory/authoring resources to encourage the development of lesson plans/instructional activities/learning materials, etc. It will possess capabilities to work with text, graphics, voice, and video materials.

Module 5

Setting: School and District administrative offices.

Description: Administrative workstation.

Purposes:

1. Provide administrative offices with capacity to input, access, gather, analyze, and report data.
2. Provide means for electronic communications between administrators and teachers, between school and district administrators, and between administrators and community.
3. Provide means for administrators to preview software, instructional plans, etc.
4. Provide office automation applications to the workstation: word processing, data bases, spread sheets, calendars, etc.

Components:

1. Microcomputer connected to a high speed local area network.
2. High resolution video display with graphics and text capabilities.
3. Local storage capacity.
4. Printer and communications services.
5. Bridge to district-wide area network (administrative).
6. Voice communications equipment.

Special Features/Requirements:

The administrative workstation will provide office automation capabilities and will offer access to instructional and administrative information systems.

Module 6

Setting: Homes of students.

Description: Home-based technology unit.

Purposes:

1. Permit students to continue their work at home, tying into the school's technology system.
2. Permit teachers, administrators, and parents to communicate via electronic mail.
3. Provide means for parents to gain access to social services and vocational information, as well as other educational opportunities.

Components:

1. Microcomputer with disk drive.
2. Video output to TV or video output and display.
3. Modem to provide communications over phone line to the technology system.
4. Either drive compatibility, upload-download capacity, or direct connect ability to permit data transfer between the technology system and the home unit.

Special Features/Requirements:

This module should have available software to support student work processing and instruction enrichment software. The module should be inexpensive, rugged, and capable of displaying output on a home television set. It should be able to transfer data developed on the home-based unit to the school system.

Using the Integrated Technology System

Envisioning how classrooms and schools will function with an integrated information technology system as described above is difficult because such systems have never existed before in this form. Teachers and administrators in Sacramento have very specific plans for how their system will accomplish goals of the SCMTS. Without visiting schools involved in the project, how does one grasp what the system will look like and what it can do in practice?

One way to portray the workings of the system is to describe a scenario of how the system might function in a hypothetical vocational education setting. In an effort to make our scenario of interest to vocational educators, especially those in Illinois, we have taken the Sacramento integrated information system and hypothetically placed that system in a school in Illinois, to be used in a vocational education context in the current Illinois education for employment environment. One scenario cannot by itself capture all the ways an integrated information technology system might be put to use, but it can at least stimulate the reader's imagination as to what might be possible.

Education for employment programs in the state of Illinois encompass educational experiences in the works of a report entitled "Visions of the Future" that "are designed to provide people of all ages with awareness, exploration, orientation and preparation for the world of work." Education for employment curricula reflect fundamental concepts which embrace the primary purpose of schooling as identified by the Illinois State Board of Education. The Board's Policy on the definition of schooling emphasizes the transmission of knowledge and culture through which children learn in areas necessary to their continuing development. Also reflected in vocational education curricula is an awareness of and a concern for the challenges affecting segments of education, i.e., rapid technological change and change in the characteristics of the work force. The scenario below illustrates how one discipline within education for employment, industrial education, might be approached for and by a student named Elizabeth using the type of integrated information technology system described above.

The Illinois Plan for Industrial Technology Education is organized into four levels of instruction beginning with elementary schools and continuing through adult education programs. The four levels of instruction are: awareness at the elementary level; exploration at the middle school/junior high level; orientation at the high school level; and preparation at the high school, vocational center, community college, and university levels. Here is our scenario:

Elizabeth enrolls in Maine High School, having come from another school where she was in ninth grade but achieving at a lower grade level in academics. She is assigned to Mr. Smith, a member of a collegial group of four teachers responsible for approximately 120 students. He guides Elizabeth through a series of diagnostic/prescriptive experiences appropriate to her prior academic history and also assesses Elizabeth's communication skills. Much of the academic assessment is made through the technology system; all of the results are entered into a computer–based student profile.

This profile is used by Mr. Smith and his colleagues to assign Elizabeth to appropriate academic course work, as well as to a peer support group that shares affective and academic experiences. Elizabeth progresses through a series of planned learning experiences focusing on communication and thinking skills across the curriculum. Many of these experiences are delivered through the technology system, which automatically updates her student achievement profile. Elizabeth's attendance patterns are also monitored for indications of 'at–risk' status.

In a typical day, Elizabeth's academic program includes large group, small group, and individual learning experiences. She is enrolled in Mr. Smith's industrial education class in which he makes a presentation to a group of 20 students using video tape and videodisc materials. Mr. Smith uses this exercise to prepare the students for small group research activities. Via a computer–based

work station in a study area, Elizabeth spends the balance of the class period preparing, on a computer, a text and graphics report to share with the large group. At the end of the day, she stops by the tutorial center for help from a senior student mentor from Maine. To facilitate work at home, Elizabeth checks out a computer and later calls a homework hot–line for help from a student teacher at a local university.

Mr. Smith has created a unit of instruction that helps students understand the factors involved with energy utilization systems. The unit is titled "Sources of Energy." In this unit, Mr. Smith wants students to understand forms of energy and how energy affects the lives of people. He then plans to explore with students different learning experiences, focusing on energy resources, technical processes, industrial applications, and technological impacts.

The 20 students in Mr. Smith's industrial education class represent a mixture of academic abilities and interests, as well as a range of socio–economic and ethnic groups, with minority students representing about 85% of the class. Mr. Smith has found the class as a whole to be willing to work fairly hard at times, but many of the students lack basic skills. In addition, some of the students appear not to have many friends at school.

Mr. Smith is particularly interested in teaching the kinds of communications and critical thinking skills the EFE system director has decided to stress throughout the curriculum. Therefore, Mr. Smith will be asking students to engage in a number of communications exercises as they learn technology concepts. He plans to take special care in teaching students skills related to analysis, particularly by asking students to engage in comparison studies. Problem solving and analysis activities are vital parts of the employability skills packets that have been adopted by the EFE regional curriculum committee.

Mr. Smith has a teacher workstation in his room. That workstation contains a microcomputer and controls that permit access to a VCR, cable television, and videodisc player. In addition, the classroom contains a large television monitor on which Mr. Smith can display information from a microcomputer and from any of the video sources. The teacher workstation also permits Mr. Smith to access an information resources center (IRC). This service provides a vast array of information resources, such as software programs, data bases, text materials, and a number of other information products. Materials from the information resources center are regularly updated and expanded, so Mr. Smith has access to the latest information products. The center provides an array of instructional management services as well as productivity tools such as word processing programs.

Also in Mr. Smith's classroom are student workstations consisting of microcomputers and printers. Some of the workstations have video equipment, permitting the use of interactive video lessons. All of the student workstations are networked with one another and the teacher's workstation. Students at each workstation can be working on individual programs, or all workstation users can be working together on the same program.

Prior to the academic year in which the unit of instruction was scheduled to begin, the EFE industrial education committee chaired by Smith had prepared a list of instructional objectives, some of which were selected from the bank of objectives available through the Illinois vocational education curriculum center. The IVCC contains curriculum standards, so Mr. Smith was able to check selected objectives against curriculum standards.

Having formulated instructional objectives, Mr. Smith electronically searches the IVCC information base to find

materials for teaching each of the instructional objectives. The computer presents a list of possible software programs and text materials, grouped by instructional objectives.

Mr. Smith also wants students to experience computations with statistics. Once again, he checks the inventory of data bases available from the IVCC. A subset of the U.S. Bureau of Labor Statistics data base contains the statistics he wants. He asks that those subsets of the larger data bases be sent electronically to the school and stored in the school's computer storage facility for use when he needs it. Finally, Mr. Smith checks the IVCC listing of holdings for maps of various kinds, discovers the center has most of the maps he needs, and requests that the center print copies of those maps.

Using a curriculum alignment system accessible electronically through the IVCC, Mr. Smith locates test items that have been coded to his instructional objectives and the materials he has decided to use. He notes, however, that the IVCC test item data base does not contain assessment items for all activities he will want to test. Therefore, Mr. Smith turns to a test development program contained in the school's storage device. This program is designed to create criterion measures for competencies that have evolved from worker verified task lists. He brings the program to his workstation and creates additional test items.

With a good sense of the range of instructional or information resources available through the IRC, Mr. Smith begins to sketch out how the instructional unit will work. He plans a mix of class, small group, and individual student activities. The unit unfolds as follows:

Mr. Smith begins with a meeting of the whole class to explain purposes of the unit. He hands out a list of the learning objectives, explains their relationship to tasks performed by workers in energy–related occupations, reviews projects in which students will be engaged, and describes how students' learning will be assessed.

The class then views a large screen monitor portions of a video tape, excerpts from the Turner Broadcasting series "Sources of Energy in America." Group discussion of the video focuses on how areas within the United States receive their energy supplies.

Mr. Smith makes an initial assignment. Each student is to select a city or town in the United States from a list Mr. Smith has prepared. Working at one of the workstations in the room, each student draws upon the information Mr. Smith has previously requested from the IVCC. Students study the topography of regions within the U.S., population density, natural resources, and industrial and social developments that may have influenced the energy resources used within a region or area being studied. Students are asked to enter the information they have found in a 'shell' (a type of computer program) created by Mr. Smith. Once students have completed their work Mr. Smith is able to develop at his workstation a summary sheet comparing data across cities. Copies of the summary are made available to the students. When appropriate, the class meets as a whole to discuss the implications of the data they have collected.

Mr. Smith's students have been engaged in studies in other subject areas during this time, of course. In addition, students have been reading sections from relevant textbooks previously identified by Mr. Smith. In about a week, Mr. Smith judges that most everyone in the class has mastered competencies identified in the unit and, substantively, the factors that are important to understanding how energy related issues influence decisions for locating major businesses and industries. Mr. Smith decides that enough understanding exists to begin individual or small group research projects. Taking into account the learning profiles of each

student which are stored in his computer, Mr. Smith develops a number of individualized inquiry projects for students, some examples of which follow:

A group of four students is asked to explore the role rivers have played as a source of energy. The four students first use a program developed in conjunction with a recent PBS television series on great rivers. Using a videodisc player and microcomputer, students engage an interactive program which depicts how population centers have developed around rivers. The program provides basic information that is supplemented by an on–line electronic encyclopedia and articles secured by students through a search of a data base. Using the word processing programs in the student workstations, students write reports based on data gleaned from these information sources, and lead discussions to benefit other members of the class.

One advanced student in the class takes on an assignment developing a survey instrument, sending it via electronic mail to two hundred students living in 15 different urban centers throughout the United States. The instrument contains 20 questions that survey respondents may answer by typing responses into their own workstations. Responses to the survey are transmitted electronically to the student in Mr. Smith's class, who uses a statistical program available from the IVCC to analyze and summarize the data. The student then writes an executive summary on the data for distribution to the rest of the class.

One of the students in the class has a severe reading problem. Mr. Smith uses a software program that stresses the development of reading skills. The teacher is able to modify the general reading program to reflect the content of the unit on sources of energy, so the student can continue to feel a part of the class.

Two students work together on a map project. Using maps previously located by Mr. Smith in the information resources center and with the assistance of the graphics package available through the workstations, the students construct a number of maps that show—more convincingly than the written word can—how topographical factors influence settlement patterns, industrial growth, transportation, and ultimately, energy utilization.

With knowledge of the kinds of information resources that are available through the IVCC system and with his own resources, Mr. Smith is able to create and monitor a number of projects. Students work at different paces and in different ways, sometimes alone, sometimes with other students or the teacher, sometimes with experts electronically brought to the classroom. Students tap a variety of data bases, move back and forth among different types of media, and complete a range of projects.

As the students complete their independent projects, Mr. Smith brings the class back together periodically to examine and learn from the work of each other. He knows that the ability to work as a team to accomplish tasks is an important employability skill that students must practice.

At some point, Mr. Smith administers an examination to all students based on the regional EFE curriculum and material that has been considered by the class. Results of the examination are collected, scored, and reported using a testing program Mr. Smith accesses through his work station. The teacher is able to determine those students who seem to have learned the material as planned and those who have not. For those who have not met the instructional objectives as measured by the examination and other data Mr. Smith has collected, the teacher develops individualized programs designed to address specific deficiencies. These programs require the use of software and text material that Mr. Smith locates by scanning the IVCC

data bank and obtaining relevant material from other industrial educations within the EFE region.

Mr. Smith's unit on energy utilization systems was created not only in collaboration with other industrial education teachers within the EFE region, but also with teachers across the state. One teacher in particular works in an EFE system nearly three hundred miles away. The two teachers compare notes and ideas on a regular basis using the electronic mail capacities of the technology system.

Now it is time for the students to communicate with each other across the miles. Using the electronic mail facilities, students are paired between the two classes and begin to share with each other the concepts they are learning. This kind of electronic communication adds greatly to the richness of the learning experience. The students gain new knowledge about the topic and learn how to communicate more effectively with people they do not personally know. The experience is highly motivating for the students, and they are gaining experience in another employability skill targeted by the EFE curriculum committee—interpersonal communications.

Also using the electronic mail capacity of the technology system, students in Mr. Smith's class contact a professor at Northern Illinois University who is an energy specialist for the Illinois Plan for Industrial Education. Students send questions to the professor who responds directly back to them via electronic mail. The professor's informative answers are not the only benefit of this exercise; the experience of learning how to use a valuable human resource is also helpful.

During the unit of study, parents are involved in class and individual student activities in a number of ways. Several parents work for a state agency that compiles statistics for the state. Using the electronic mail capacity of the technology system, those parents actually prepare a data set from their office and transmit that data base to the school, where it is used by several students in a research project. In the case of two students in the class, Mr. Smith experiences some difficulties; the students are encountering an unusual amount of trouble with one part of the unit. Mr. Smith contacts parents of the two students and asks if they will help their son or daughter with the unit. The parents agree; Mr. Smith checks out two microcomputer terminals and modems from the school, brings the terminals to the students' homes, gives the parents a brief review of how to turn on the machines and how to connect with the school's systems. For the next several weeks, those parents work via computer with their children in the areas where trouble was being experienced. Both parents and children profit from the experience.

Mr. Smith's EFE system had spent time cultivating partnerships with several local businesses. Mr. Smith involves people from those businesses in his instructional unit. One of the businesses, Commonwealth Edison, agrees to send a representative from the company to talk with interested students about careers with utility companies. Two of the students prepare a series of questions for the guest speaker, and conduct an interview with her before a television camera. The session is recorded, and later played back to the whole class, stimulating a good bit of discussion.

In still another instance, Mr. Smith arranges for a teleconference, using the local cable television company facilities (a donation from the company!), connecting students in the class to the office of the mayor in four cities. The mayors, themselves, are kind enough to join the teleconferencing for a time. Mr. Smith's students had once again prepared a number of questions for the mayors and their aides. The conference is a spirited experience; students gain new insights

regarding the effects of technology on the four communities. Expenses for the teleconference are shared by one of the local business partners in Mr. Smith's school district and the regional VICA club.

As Elizabeth continues her education, she progresses to perform at or above grade level in academics. She takes an interactive television course in technology and cultural relevance via satellite and a geometry course via cable from Main High School. At her high school, Elizabeth pursues her interest in ITE by working with electronics engineers (using computer–assisted design) one day each week through the regional cooperative education program with local high–tech businesses. At each school, Elizabeth is a member of a peer support group, continues emphasis on communications, problem solving, and other employability skills, and is assigned to an inter–disciplinary group of teachers for counseling and guidance. Through an Advanced Placement Cooperative Agreement with Triton Community College, Elizabeth continues her education and transfers to a four–year institution to complete a degree in electrical engineering.

This scenario, while necessarily incomplete, provides a sense for a dynamic instructional environment envisioned for students enrolled in education for employment programs utilizing integrated information technology systems. The scenario exhibits in a more concrete form some of the foundational perspectives on technology applications that may be evident in education for employment systems of the future.

Current Status of the SCMTS

Developing plans for an integrated information technology system is one thing—actually implementing those plans may be quite another. What is the current status of the SCMTS?

The classroom of tomorrow (the technology training center) has been installed in an elementary school classroom at Jedd Smith School. That classroom is being used for teacher training and for demonstration purposes. The classroom has a variety of vendor hardware and software, a teacher workstation, large screen television projection capability, and all of the other technology components that have been envisioned for a classroom of the future. The room is heavily scheduled as teachers throughout the Sacramento district receive training for using technology effectively in their own classrooms.

The three schools in the Sacramento Model Technology Schools project (elementary school Kemble; middle school Goethe; high school Burbank) have been involved in various activities during the first 18 months of the project, although the Burbank participation will not begin in earnest until the fall of 1989. At the time of this writing, model technology classrooms have been established at Kemble and Goethe. A useful way of summarizing the current status of the MTS project is to cite the year end reports made by the project director and the coordinator of training, from the May, 1989, newsletter produced by the SCMTS:

With both Kemble and Goethe now fully involved in the MTS project, the pace has picked up considerably, but so has the excitement. Teachers at Kemble are immersed in developing and testing their technology–integrated, thematic curriculum units as well as tackling additional and more sophisticated uses of technology. Some staff members have become such experts in the use of specific technologies that they have conducted very successful workshops. Teachers at Goethe have been involved in training all year, not only in the use of technology but in instructional strategies and the writing process. The final capital improvements were completed recently, and the schoolwide networks are now running so teachers are like 'kids in a candy store' with all the technological options now available for instructional use. Meanwhile, the administration and core team from Burbank have been meeting regularly to finalize plans as we move towards implementing the program there.

One of the added bonuses within the MTS is the opportunity for articulation between schools. Sixth grade teachers at Goethe have participated in training sessions with the Kemble staff—a start in bridg-

ing the gap for students as they move from Kemble to Goethe. In April, several teachers from Goethe spent the day in classrooms at Kemble, and all indicated that the experience was extremely worthwhile. With the completion of their capital improvements, the Goethe staff hosted a reception in their 'new' facility. The benefits gained from all these activities have convinced all of us that we need to continue to make such opportunities available in the future.

As the 1988–89 school year draws to a close, those of us directly involved in the MTS recognize that there have been many others who have contributed to our success to date. In addition to all our business partners, many departments within the district have given their time and talents in assisting us. Personnel from Information Services, Curriculum Services, Research and Evaluation, Magnet and Integrated Education, Maintenance and Operations, Budget Services, Purchasing, and Accounts Payable have been there to help when needed, and their assistance is greatly appreciated. As we look ahead to next year, we look forward to implementing the high school segment as well as watching continued growth at Kemble and Goeth.

With the completion of the installations of the video and instructional networks, training has taken rather different focuses at our elementary and middle school sites. Building upon last year's inservices, the teachers at Edward Kemble are much more focused on curriculum development while fine tuning their technological skills. At the staff's request, technology related training has been kept to a minimum. With their base of in–house technology 'experts', much of their support has been on an informal basis—teachers troubleshooting for each other as problems occur. In addition to the informal sessions, teachers met with representatives from Education Systems Corporation to learn how to access the wide range of reading, language arts, and mathematics programs available through their system. Two release days were planned for the Kemble staff. Both days targeted the improvement of student writing, a key component of the MTS project. During the sessions, teachers learned strategies for combining technology with peer response groups working on the revision and editing of student writing; participated in grade level team sharing of successful lessons which incorporated literature, writing, and an appropriate integration of technology; and designed 'break–out' sessions to address more specific needs such as troubleshooting on the network, incorporating ESC programs in the curriculum, interactively using Instructional Television programs, and merging LOGO with robotics. As a part of our across–site articulation, sixth grade teachers from C.M. Goethe attended both release day activities. Of the events described, the most popular by far was the sharing of lessons. The Kemble staff was amazed and delighted by the wide range of approaches to making effective use of technology while being sensitive to the state frameworks and curriculum guides.

With a foundation of good instructional strategies in place, the teachers of C.M. Goethe have spent far more of their time this year becoming acquainted with the variety of new technologies available to them. Through a process of phasing in small groups of teachers, the staff has had opportunities to attend sessions that have ranged from the basics of turning on a computer to beginning to access resources through the video and instructional network. Early on, the teachers established a buddy system which included a telephone 'hotline' list. This has enabled them to immediately solve most of their problems regardless of the time of day, or their work location. With comfort levels high, and school–wide access to video and instructional programs, many of the teachers at Goethe are already busily at work developing their own integrated units of instruction.

While working through the planning phase, teachers from Luther Burbank have already been attending conferences and district inservices to develop their skills as they prepare to receive the new systems.

Teachers from all three sites are looking forward to attending the wide range of workshops offered during Sacramento City Unified Schools District's 1989 Summer Technology Institute during the last two weeks of June. In addition, staff members at all sites are working with the project team to design specialized inservices to be offered prior to the start of school in September, 1989.

There have been problems, of course, as one might expect in the installation of any technology system as complex as the MTS. Shipping of equipment to arrive in a timely fashion often presents difficulties. Wiring poses unique problems for the schools, particularly older physical facilities. Security systems need to be installed in several classrooms. All of

these items have received attention and problems have been and are being solved.

The project is too young to describe learning outcomes of the model technology schools project. As a five–year enterprise, it will no doubt be fully five years before it can be determined if the instructional goals set for the project were achieved. An ambitious research program has been undertaken to provide data whereby issues of effectiveness can be addressed.

But it is exciting to see the project underway. It provides an exceptional opportunity to test the notion of integrating information technologies in unique ways. Much will be learned from this enterprise. Time will tell how effective this approach to instruction is, and for whom.

Issues

The Sacramento City model technology schools project is very much in its infancy. Many issues have surfaced with respect to implementing integrated information technology systems. A few of those issues are described below in a preliminary fashion, given the early stages of this project.

Planning for implementation. Planning is essential to the development and implementation of an integrated information technology system. A great deal of planning has been done by Sacramento personnel. In fact, it is probably fair to say that a year's worth of concentrated planning was necessary to get this project off the ground. The details and options are many. Without an adequate technology plan, the complexity of a system such as that being integrated into the Sacramento instructional program would simply fail. Unfortunately, additional research is needed to recommend all the segments and details of a comprehensive technology plan. As the Sacramento plan unfolds, we should learn more about that issue.

Logistics. Another lesson learned in trying to implement a complicated integrated information system is that logistics become all–important. It takes time to buy equipment; it takes time to get it installed properly. There are many decisions involved in matters such as wiring, security, and facilities, particularly when the technology system is being placed in buildings and classrooms which were not designed for such systems. The message here is simple: any district wishing to implement large scale technology systems must schedule sufficient time and must develop ample patience for solving logistical problems..

Staff development. Anyone who has worked with attempts to implement technology systems in education recognizes the centrality of staff development to the success of those enterprises. This has certainly been the case in Sacramento. The Sacramento project entails a transformation in the teaching and learning processes that occur daily in that district. For such a transformation to occur, both teachers and administrators must prepare to think in new ways about teaching and learning. Staff development has been an item of great importance in the Sacramento planning process. Already, major staff development activities have been undertaken. Current evidence supports those efforts as of primary importance to the long–range success of this project.

Sacramento school personnel have expended considerable time and energy creating a vision for staff development. Attention has been given to what ought to be taught, as well as to how and when. There are no simple formulas. Sacramento will continue to learn as it engages in staff development. The staff development issue is complicated not only because of necessary ambiguities about the appropriate content of an effective staff development program, but also because of the time commitments required on the part of teachers and administrators to participate in training activities. This is not an inconsequential issue for any district or region considering the utilization of a complicated technology system.

Chapter 5

Instructional Technology Applications In Industrial Training: The Nuclear Power Industry

The preceding cases described in this *Notebook* were schoolbased examples of technology applications. Educators are most interested in schoolbased examples for obvious reasons. But businesses and industries also use instructional technologies to provide various forms of training for employees. Some applications of instructional technologies in the business sector may have conceptual, if not direct, implications for school use. Because businesses do use instructional technologies in ways relevant to vocational education, we include one case in this *Notebook* of instructional technologies for industrial training.

Dr. William Widen authored this case study of technology uses in nuclear training. Bill is Academic Dean at the Westinghouse Nuclear Training Center in Zion, Illinois, and has a great deal of experience in the training business. Because Bill also has a degree in vocational education, we felt he was especially qualified to write about technology in training with the vocational education audience clearly in mind.

As most vocational educators read this section, especially near the end when Widen describes large simulators that cost $14 million for initial purchase price, readers may likely be heard muttering about how schools will never afford the technologies used by industrial training departments. But once again, we ask you to consider the *concepts* underlying business applications of instructional technologies.

On to this look at instructional technology applications in business training. Bill's report begins with a "futures scenario":

April 3, 2007: Geronomo Bay Nuclear Generating Station

Mike Reardon banged his door shut, stalked across his office, and then slumped into his executive swivel chair. He was angry—angry at his staff and angry at himself. He had shouted and generally made a spectacle of himself in public; it was time he sat back and regained his composure. He turned his

chair to look out his office windows onto the lake. It was early spring now, and soon the Great Lakes merchant marine traffic would return—huge freighters carrying their payloads of cool and grain to and from the harbors that served as conduits for the manufacturing and agricultural belt of the Midwest. He smiled as he remembered that old adage: the only thing that is constant is change. Change in seasons, change in economics, and change in people could all be counted upon.

Change had come quickly and radically to the electric utility industry. In 1998, Congress had deregulated the generation side of electricity. Previously, each electric utility was a monopoly regulated by its governing public utility commission. The utility had a right to a modest profit, as determined by the public utility commission, but the utility also had a monopoly to generate and distribute electricity within its own region. Congress seemed to be big on deregulation: first the trucking and airline industries, then electrical generation. What this all meant to the utilities was survival of the fittest; those that could produce electricity with the greatest reliability and efficiency and the lowest costs would continue to sell it on the open market. Those who did not or could not produce at competitive rates were or would soon be out of business.

Mike was appointed the manager of Geronomo Bay Nuclear Generating Station three years ago. As nuclear power plants go, his was one of the largest. Geronomo Bay could produce up to 1,100 megawatts of electricity, enough to supply the entire electrical needs of a city the size of Pittsburgh. In addition to that, Mike was producing electricity for about 1.75 cents per kilowatt hour. That was pretty good, since the cost of producing electricity by coal was about 4.4 cents per kilowatt hour, and the cost of electricity generated by oil was approximately 15.8 cents per kilowatt hour. So the relatively low cost of the electricity Mike produced, plus the sheer magnitude of electricity he could generate, made Geronomo Bay the flagship plant of Great Lakes Edison. Most of the time Mike enjoyed being at the helm of his flagship, but today the seas were a little rough.

Mike kept thinking about change in general and how his own career and responsibilities in particular had changed. Nineteen years ago he was graduated with a degree in engineering and was commissioned into the nuclear Navy as an officer. He studied to learn all of the technical aspects of the nuclear submarine to which he was assigned. After six years in the Navy, he studied to learn all the technical aspects of the Geronomo Bay power plant. The plant was so much bigger and more complex than the submarine, but study had paid off. First, he was licensed as a senior reactor operator (SRO), then in succession became the onshift manager, the radiochemistry controls manager, and the operations manager. To finally become the plant manager was the fulfillment of a dream. All the technical training boiled down to a job where economic common sense was the most often used measuring stick and evaluation tool. Mike had a problem all right; his plant was offline, not producing electricity, and that was costing Great Lakes Edison about a million dollars a day.

Mike reflected on how this situation had come about. Two weeks ago operators had detected a vibration in the #3 reactor coolant pump. Reactor coolant pumps are pretty hardy; they weigh in at 6,000 horse power and they pump about 89,000 gallons of water per minute. So, when there is a vibration in a reactor coolant pump, it is essential to shut down the plant and repair the pump before any true damage occurs to the pump or the plant. Unfortunately, this is a time consuming job since it takes

several days to shut down the reactor, cool down the plant, and drain the water from the primary system. His maintenance crew had diagnosed the vibration as a faulty pump bearing. After the shut down, cool down, and drain down they had to separate the 6,000 horsepower motor from the pump and replace the pump bearing. They then refilled and pressurized the system and started the pump. The vibration was still there. At that point, the maintenance crew decided it must be a lower motor bearing. This time, the pump could stay in place, but the motor once again had to be separated from the pump. The maintenance crew replaced the lower bearing, realigned and bolted down the motor, and started the pump. The vibration was still present. After the replacement of the upper motor bearing the pump was started for the third time, and the vibration remained. Finally, the maintenance manager speculated that the seal package was out of balance. It was, and 13 days and nearly 13 million dollars) later, Geronomo Bay was back online generating electricity.

That morning, Mike had talked to his maintenance superintendent and critiqued the performance of the previous two weeks. Unfortunately, everyone's emotions ran high, and the scientific analysis became a shouting match. But now Mike was seeing the points his maintenance superintendent had made: there had never been a problem like this before at Geronomo Bay; the reactor coolant pumps are in the containment section of the plant, so no one can stand next to them and listen to them when they run; and a pump vibration could be caused by one of twenty things. What his maintenance crew really needed was top–notch diagnostics and trouble shooting training, but where can you get this kind of training? The type of training needed was tangible, hands–on training, not textbook reading. But where and how can that type of training be given?

People don't just haul around 80 ton reactor coolant pumps with various malfunctions so that maintenance crews can experience the difference between a pump bearing vibration and a misbalanced seal package.

As Mike contemplated this dilemma, he remembered a friend at another plant telling him of a portable maintenance simulation lab. It was offered by one of the Nuclear Steam Supply System (NSS) vendors, and it used sophisticated simulation and computerized training techniques to aid in diagnostic trouble shooting. Mike phoned his training manager and asked him to get this portable lab out to Geronomo Bay as soon as possible. The training manager replied, "Mike, that thing costs about $125,000 for a week. We can't afford that!" Mike replied, "After being off line for 13 days, we can't afford not to have it. Get it here as soon as you can."

May 21, 2007: Geronomo Bay Nuclear Generating Station

Nick Lagaric was skeptical. He had been a maintenance man at Geronomo Bay for 22 years, and a good one at that. That's why he had been promoted to maintenance foreman, maintenance shift supervisor, and finally maintenance superintendent. He had learned the station from the ground up, and he wasn't sure what some newfangled simulation lab was going to teach him. To be sure, he realized that the misdiagnosis on the pump probably caused 8 or 9 extra days offline, and he certainly didn't want that any more than anyone else in Great Lakes Edison. But in 22 years he had never encountered a problem like that before, and sometimes you just have to live and learn. He wasn't opposed to learning new things that would ultimately make Geronomo Bay more efficient, just skeptical of how a so called simulated condition could really help anyone function with a real world problem.

Nick had to admit, though, that this portable laboratory was a pretty slick design. There were four 40 foot trailers, the same as you would see behind a semi-tractor truck. These four trailers locked together in a perfect square. Two of the trailers had accordion–like expansions that pulled out and coupled in the middle to form a small classroom. When it was assembled, it looked like a square donut, with all of the large laboratory equipment in the trailers on the outer perimeter of the donut and all of the student desks and large screen projection equipment in the square center.

Nick also had to admit that some of the laboratory equipment looked fairly impressive as well. There was a model of a reactor coolant pump in one trailer. It was about one quarter the size of a real pump, but it was very detailed. In the other trailers were high fidelity models of steam generators, a reactor vessel head, demineralizers, feedwater pumps, and a turbine/generator. In addition, there were miscellaneous smaller motors, pumps, and Limitorque valves. Also, there was a bundle of computer equipment sitting around. Even if he didn't learn much, Nick thought the experience would be at least entertaining.

The first several days of training focused on general diagnostic skills, classroom theory refresher, and the smaller pumps and motors. Some of the simulation equipment was truly fascinating. For example, although none of the motors was real, each looked authentic on the outside. When a motor vibrated, it really shook. When a motor malfunctioned, the amperage readings for the current reflected the malfunction, and when a motor shorted out, an aroma was emitted. All of this was done by computer program, but it was very realistic. Although the actual teardown of the simulated motors was not possible, the students did a simulated teardown by interactive video disc. In this situation, the student was allowed to follow procedures, select sequential steps, and see his or her actions implemented on a video. It was just like a video tape, except that each student determined his or her own script. All in all, the simulated lab was impressive. But, could it help an accomplished maintenance man's diagnostic skills on the bigger equipment components?

To Nick's delight, diagnostic trouble shooting of reactor coolant pumps began on Wednesday afternoon. The instructor programmed in a vibration and asked the class to diagnose the cause. Nick, who was now the voice of experience, said it could be a pump bearing, a lower motor bearing, an upper motor bearing, or an out–of–balance seal package. The instructor quickly confirmed that indeed, it could be any of these, but which one? He challenged Nick to use the simulator to complete his diagnosis.

With a bit of prodding from the instructor, Nick began checking current and voltage readings for the running pump. All of the readings appeared normal, indicating no excess friction to cause an additional load. The flow rate from the pump also appeared normal, which would indicate the pump was running at full speed and horsepower. In addition, the instrumentation indicated no excessive heat build up in any of the bearing regions. Samples were taken from the pump seal water and the lubrication oil, and no sign of metal shavings was found. Finally, everyone agreed that the vibration was somewhat rhythmic and harmonic, not of a growling nature. And, as the pump was increased and decreased in RPM, the vibration was more pronounced at different speeds and wave–lengths. It seemed so simple now, diagnosing the pump and looking at the interactive videodisc for procedures and examples. There was no excess friction, so the bearings were intact. The vibration was consistently more pronounced at certain wavelengths and RPM, so it was a constant imbalance, not one that

occurred sporadically. Nick smiled and reflected. If only this $125,000 per week training tool had been on–site six months ago, his plant might have saved $8 million in down time. New fangled simulator or not, it was the best diagnostic experience he had ever seen. Nick was becoming a believer!

The nuclear power industry is constantly striving to improve the quality of its training programs. It is an article of faith within the nuclear community that well trained people are the most important factor in ensuring safe operation. The United States Nuclear Regulatory Commission recently stated, "a commitment to excellent training is one of the best investments a utility can and must make" (Zech, 1987).

The advent of computerized training tools has helped the nuclear industry improve the quality and sophistication of its training. The balance of this case study will include a delineation of some of the various computerized and other training tools that are used in the nuclear power industry. It is hoped that this brief analysis of case studies will demonstrate how emerging technologies have improved both the quality and the cost effectiveness of training techniques in an industry that relies upon human performance as the heart and soul of safe operation.

Each description below has been formatted to include: need (the training or behavioral performance required); training tool (the computerized or other training device/technology utilized to serve that need); and outcomes (the attainment of the needs plus any cost/benefit analysis data if available). The descriptions below have been sequenced to generally ascend in terms of sophistication and complexity. That is to say, the more complex the tool, the more capable it is of satisfying higher order cognitive, affective, and/or psychomotor tasks. Also, as one might suspect, the more complex the device, the more costly. The rule of thumb in the nuclear industry, similar to any competitive industry, has been to meet the performance training objective in the most cost effective manner possible.

The following training tools will be described in this chapter:

- Study Pac System
- video graphics
- CAD/CAM training graphics
- video show presentation system
- computerized exam bank
- models
- static
- dynamic
- mock ups
- computer based training
- interactive video disc
- partial scope simulation
- artificial intelligence
- full scope simulation

Study Pac System

The Need

Reviewing case studies of operational events represents a major part of licensed reactor operator requalification. Indeed, compiling and studying the details of operational incidents throughout the industry is a very effective way to prepare for abnormal or emergency incidents that may occur at one's own plant. The Nuclear Regulatory Commission requires that all licensed operators review Licensee Event Reports (LERs) and Significant Operating Event Reports (SOERs) as part of their annual requalification. The licensed operators are then examined to assure that they have studied and properly analyzed these industry lessons learned.

In most cases, LERs and SOERs are reviewed through required reading packages. Operators are then required to acknowledge that they have reviewed the material sufficiently by signing their names to the package. The operators can expect to see review questions of the incident at a later date. As one might conclude, there are several problems with this system: 1) The reading material is often lengthy and boring, 2) important aspects of the incident are not always emphasized or highlighted in the literature, and 3) proof of understanding and competency is delayed until an examination is conducted at a later date.

Training Tool

The Study Pac system is a registered trademark of Teaching/Learning Technologies Corporation. The system consists of a notebook which contains a hand

held computer. The computer responds to the touch input of the student and can be programmed in a variety of ways to respond to student inputs and/or record student responses.

A typical self paced unit of instruction using the Study Pac system proceeds in the following sequence:

1. The instructor develops a unit of instruction which, in this case, delineates recent operational occurrences in the nuclear industry. Interspersed throughout the unit of instruction are multiple choice or true and false questions.
2. The trainee selects from the library or receives from the training manager the instructional unit, and inserts the edge of the booklet into the hinged edge of the Study Pac notebook. The coded edge of the instructional unit will program the correct answers to the Study Pac system.
3. The trainee completes the unit of instruction, answering the multiple choice or true and false questions interspersed throughout the module. At the instructional designer's discretion, the Study Pac system can provide immediate feedback to each trainee input, or it can record all responses and provide the trainee with a final score for overall performance. If the feedback option chosen is the final score method, the Study Pac system can direct the trainee back to the responses that he or she answered incorrectly.
4. An optional feature for the Study Pac system is a plug–in module that records trainee responses. This small, portable module can then be plugged into a microcomputer system that will score and record the student's responses, create a class file of responses for the instructor, and tabulate statistical results for the entire examination as well as conduct test item analysis.

Outcomes

Utilizing the Study Pac system to review and study recent industry events has netted several positive outcomes:

- A permanent record of each trainee's responses and competence is generated by the Study Pac system.
- Statistical analysis of the training module as a whole, as well as individual item analysis, is calculated automatically by the Study Pac system.
- The Study Pac system allows total self paced capability. Trainees may check out a unit at any time, study the unit, and complete the examination without requiring any instructor time. By use of the recording module, the exam can be input into the computer via the instructor at a time of his or her convenience.
- Trainees have indicated that the Study Pac system is fun, efficient, and provides enhanced learning. In particular, the enhanced learning results from focus on and immediate feedback to questions throughout the test.

The Study Pac approach requires increased instructor time (compared to the conventional required reading package) to design, develop, and author a unit of instruction. However, the payoffs of documented trainee competence plus enhanced learning appear to more than compensate for the added development time. A Study Pac system, including Study Pac notebooks for 30 trainees plus the optional computerized scoring system, represents an initial investment of about $21,000. Considering that nuclear power plants generate revenues of $500,000 to $1,000,000 per day, the Study Pac investment appears to be very worthwhile.

Computer Aided Design Training Graphics

The Need

Nuclear power plants are a complex assemblage of piping and electrical instrumentation systems. Training of operators requires intense and detailed study of piping and instrumentation drawings. Unfortunately, no two nuclear power plants are exactly alike. Therefore, the development of plant–specific training materials requires system descriptions augmented by detailed drawings. From

the period 1978 through 1985, the Westinghouse Nuclear Training Center averaged 5,100 hours (nearly 2 1/2 person years) per year of drafting time to complete the drawings needed to augment curriculum materials.

Training Tools

In 1986, Westinghouse invested in a computer–aided design drafting system. This system represented a capital outlay of approximately $19,000. It is driven by a microcomputer using commercial software and add–on peripherals such as a D size plotter, a monitor, and a Bernoulli box. The system is capable of producing detailed, multicolored drawings up to 22" x 34" in size. In addition, the system can produce color transparencies or slides.

Outcome

Overall, the system was able to reduce drafting time by approximately 38%. Considering 5,100 hours of drafting items per year at $12 per hour, this represents a savings of nearly $24,000, enough to pay for the capital investment in one year.

A more detailed look at time savings for specific types of work is as follows:

- One line detailed drawings of a piping or instrumentation system represented a time savings of about 15%.
- Detailed cut away drawings of components such as pumps, valves, and steam generators represented no time savings. That is, it takes approximately the same time to create these drawings by hand as by computer.
- Revisions of any existing drawing already generated by the CAD system represent a time savings of approximately 90%. Since a nuclear power plant is always in a state of engineering revision and improvement, and since the power plant operators are required to be cognizant of these changes, drawing revisions and upgrades represent a major portion of the drafting department's time.

Video Show—Presentation System

The Need

Training organizations are in constant need of visual aids such as transparencies or slides for presentations. It is the goal of any presenter to make these visual aids neat, professional, and crisp in appearance. Naturally, the use of graphics and color augments the quality and attractiveness of the visual aid.

Within the nuclear power industry, many presentations can be considered to be standard or somewhat standard. For example, a standard systems presentation such as the Chemical Volume Control System (CVCS) may be delivered to various employees either intact or as a refresher perhaps two to three times per year. Unfortunately, there are always engineering changes and alterations being performed on a system such as CVCS. For a vendor such as Westinghouse, this problem is amplified. Westinghouse may provide 6 to 10 CVCS lectures per year to various power plants, but each power plant's CVCS system is slightly unique in design. Hence, the bottom line need is for a visual graphics presentation system that offers ease of authoring, high resolution detail, pre–programmed graphic features, and ease in modification.

Outcome

Since purchasing the video show system in 1987, Westinghouse has utilized the system to develop numerous visual aids for presentation. Similar to the CAD system described earlier, the Video Show represents little to no cost savings for the initial design and development of complex visual aids. However, the revision of visual aids already contained on a Video Show computer disc represents tremendous cost savings. Perhaps the greatest advantage of all is the professionalism of presentation delivery that the Video Show adds. In particular, it is easy to operate by remote control, its graphics are crisp and clear, its pre–programmed library of characters and graphics is adequate for typical lectures, and its transitions from one visual aid to another are entertaining. The bottom line is that a computer generated

presentation system such as this cannot change the instructor's message, but it certainly can enhance instructor presentations with professional visual aids. Finally, we have learned that combining Video Show visual aids with segments of video tape, all presented through a large screen video projector, provides a very powerful presentation.

Video show systems range in price from a basic system of about $6,000 to a sophisticated system with peripherals at about $14,000. Certainly the ease of revising visual aids has proven cost effective in terms of diminished instructor time. It is far more subjective to measure the value added by the crisp and professional quality of the graphics; however, it is a value which everyone acknowledges wholeheartedly.

Computerized Exam Bank

The Need

A major portion of licensed operator training is based in theory ,that is, the principles of nuclear fission, radiation safety, nuclear physics, and thermodynamics. Although different styles and models of reactors will apply the theory in somewhat different ways, the principles themselves never change. A vendor such as Westinghouse teaches and examines trainees upon these principles over and over again. Examinations are constructed from an examination bank, an assemblage of questions that have been categorized by topic or subject area. As an instructor develops an exam, he or she selects questions from the bank, devoting appropriate weight to specific topical areas of the subject matter. Constructing such an exam by hand generally requires four to six hours of instructor time. Naturally, the instructor must make certain that each exam is different or unique from others, since classes generally share their exams with subsequent classes. After the exams are graded, instructors must calculate and document elementary statistics for test item analysis, thereby constantly evaluating and refining the validity and reliability of the exam bank. Any means of time savings in the exam construction and/or follow–on item analysis would represent significant cost savings to Westinghouse, for approximately 30 to 50 of these types of exams are generated each year.

The Tool

A computerized examination bank was designed and developed to perform the aforementioned tasks. The system equipment consists of a Genius VHR (full page, high resolution) Monitor, a QMS Laser Printer, and EIT Personal Scanner. This system utilizes existing software products for text graphics and database processing and is compatible with any IBM microcomputer product except PC Jr. The system enables the instructor to perform the following three functions:

- To modify exam banks and input and edit data.
- To generate exams, manually and automatically. The computerized exam bank system automatically prevents redundant use of any questions during a class training cycle.
- To grade exams and maintain records. The system performs automatic grading of all multiple choice questions, with manual grading of all other answers. It also performs automatic records updating and automatic question validity updates. It also alerts the instructor of statistically invalid questions and prevents their use until updated.

The routine tasks of data entry, grading of objective portions of the exam, and exam generation can be performed by an administrative technician under the review and supervision of an instructor. This system significantly reduces the amount of instructor workload and also maximizes the efficiency of the administrative clerk.

Each system is capable of managing at least 6000 questions per area of training (e.g. reactor operator as a typical area) and, at most, 12 areas per system. Each question is correlated with up to five objectives to allow auditing of question soundness. Output of this correlation data in print is lengthy, but visual review is simple. Along with the exam bank is a roster bank of student records corresponding to 12 areas, up to 30 classes per area, and at least 20 people per class. Output of the roster bank data allows an auditor ready access to the examination structure for any class, either active or archived.

The program employs a four level architecture. There can be hundreds of exam banks. Each bank can be divided into hundreds of categories, each of

which, in turn, can have hundreds of areas. Finally, there are questions for each area. The system randomly selects questions based on the top three tiers adjusted for level of difficulty and point values, and the examiner can modify the resulting questions to take into account questions already discussed in class or other extraneous factors.

Perhaps the most noteworthy aspect of this program is its sophistication. It can merge text and graphics, both on the monitor and the printed pages. It can be run in a network environment and all materials, text or graphics, can be added to the system using an optical scanner. It contains the Greek alphabet for engineering purposes. In addition, what you see is what you get: x–squared appears as x^2, not as x2. Finally, it can work on either a regular IBM monitor or a full–page monitor, which enhances the user's ability to implement its graphics capabilities.

Outcome

The system computerized examination bank has demonstrated several major advantages:

- the ability to save significant amounts of time for exam construction (75% savings);
- the ability to reference and record exam questions to objectives; and
- the ability to perform test item analysis and, thereby, improve the overall quality of examinations (65% savings of time).

Overall, the significant time savings have equaled a dollar savings of about $16,000 per year, approximately 2/3 of the cost of the exam bank system. In addition to the savings it has realized, Westinghouse has marketed the computerized exam bank system to a number of nuclear power plants and the United States Nuclear Regulatory Commission. The internal cost savings plus the sale of a powerful training tool to others, has provided a handsome return on investment for an internally generated idea.

Models (Static and Dynamic)

When dealing with massive components, complex designs, and macroscopic scale fluid dynamics, it is not always possible nor practical to utilize the actual component or plant for training purposes. For example, a reactor vessel is approximately 40 feet high, totally enclosed so that none of its internal subcomponents can be viewed, and located in a high radiation area to which there is limited access. Similarly, a reactor coolant pump displaces water on a massive scale: 89,000 gallons per minute. In each of these cases, training models are used effectively to teach the design and dynamic principles of the plant on a more easily understood microscopic scale. These are several types of such models, as follows:

Reactor Vessel Model (Static)

The Need

Licensed operators need to understand the design, function, and teardown/reassembly of the reactor vessel and its subcomponents. This knowledge is essential for safe operation and refueling operations. Training of operators regarding the vessel is not practical by viewing the vessel in the plant, due to its massive size and location in a high radiation area. High resolution graphics and cut away pictures are helpful but not totally effective in demonstrating the teardown and reassembly of vessel components during the refueling process. The ideal tool would allow the trainee not only to see but to actually perform teardown and reassembly procedures.

Training Tool

A reactor vessel model has been designed and molded of plastic and built to scale, containing high resolution detail. The model and its subcomponents are able to be disassembled and reassembled in a realistic manner. Trainees are allowed to see and touch all of the subcomponents and enjoy the disassembly and reassembly process. They fully comprehend the relationship of the subcomponents, including the manner in which subcomponents interlock within the internal configuration.

Outcome

The reactor vessel model can be credited with a number of "gestalts," that is, allowing students to comprehend the big picture of how all subcomponents fit together to form a complex assembly. In terms of cost/benefit analysis, we have no empirical data that the model has offset its investment cost. However, simple conjecture would indicate that at a cost of $13,000, the reactor vessel has more than paid for itself by diminishing refueling time. For example:

- Revenues generated by nuclear power plant = $1,000,000/day = $41,666/hour
- Cost of model = $13,000

The model cost is thus the equivalent of expediting the refueling process by 20 minutes.

Pump and Heat Exchanger Model (Dynamic)

The Need

Thermodynamics, heat transfer, and fluid flow are the heart of a power plant. Within a nuclear power plant, energy resulting from fission is given off as heat. This heat turns the water to steam, the energy in the steam is directed at turbine blading to turn turbines, and the turbines turn a generator which produces electricity. The operator must be knowledgeable in all aspects of this energy conversion process to assure total safety and maximum efficiency.

Nuclear power operators must know and apply pump laws, fluid and piping laws, and complex formulas for heat transfer. Plant efficiency— fission or thermal energy (the input) versus electricity generated (the output)—is most closely related to the operator maximizing heat transfer and minimizing fluid or mechanical friction. Allowing a trainee to apply these laws and principles is not practical on a working plan. However, it is essential that trainees be allowed to experiment with the principles in order to fully comprehend the dynamic interrelationships of the thermodynamic and fluid flow laws.

Training Tool

The portable fluid systems laboratory was designed to produce meaningful and accurate data for: centrifugal pump curves, pump laws, heat transfer rates for single pass heat exchangers operating in parallel or counterflow configurations, heat transfer coefficients; and the effects of fluid mass flow rate and velocity on convective heat transfer coefficients. These models require about fifteen square feet of table space. Students can speed or retard pump motors, regulate valves and generally operate the fluid flow principles of the model similar to those in an actual plant.

The models are used in conjunction with a series of experiments which delineate:

- pump characteristics
- multiple pump operations
- system characteristics
- pump laws
- system flow control
- partial void formation
- heat transfer equations
- overall heat transfer coefficient
- convective film coefficient

Students are able to alter pump speed, flow paths, and flow rate in order to calculate heat balance and efficiency figures. Principles which apply macroscopically in a nuclear power plant are understood and applied microscopically through the plant models.

Outcome

The fluid systems laboratory was originally developed by Westinghouse to supplement and apply the principles of thermodynamics. As such, the models were used in conjunction with Westinghouse's standard Thermal Sciences course. At an initial development cost of approximately $23,000, it was envisioned that the models would be a cost effective means to show operators how to increase efficiency. No doubt, the pump models have fulfilled this desire. However, one unexpected outcome was the overwhelming receptivity shown to the models by our trainees/clients. In the past several years Westinghouse has sold the models and lab books to nearly a dozen nuclear power plants for use by their own training departments. These sales have

not only allowed Westinghouse to recover its initial investment costs, but have permitted a handsome return on investment for the idea as well.

As each pump and heat exchanger model is constructed for sale to a utility, its pump rate and flow curves vary slightly due to the individual and unique characteristics of each motor plus variations in solder on joints, etc. Because of these minute yet unique characteristics, each experiment manual must be matched or tailored to the model by fine tuning the constant factors in equations. This is done by a specially designed computer program which utilizes unique flow and pump head readings to automatically adjust all parameters of the students' and instructors' lab manuals. Hence, one more application of computer assisted training.

Mock Ups

The Need

A nuclear power plant simulator is a replica of all control boards, dials, switches, and instruments contained upon the actual control board of the power plant. As far as the operator is concerned, it appears identical to the plant. However, the simulator's control board is connected to a computer instead of the actual plant. In this regard, the simulator is able to replicate, via control board response, all of the responses a plant would have under normal, abnormal, and emergency operating conditions.

Each nuclear power plant in the United States is unique; no two plant sites are exactly alike. Although most plants own their own plant-specific simulators, not all plants own one since a simulator costs between $10–14 million. Westinghouse owns two simulators, each modeled to an actual plant that Westinghouse designed. Using these two simulators, Westinghouse trains not only the operators of the replicated plants, but the operators of those plants that do not own their own simulators.

Simulator time is very valuable; it costs between $500 and $600 per hour. Since each plant and each control board is unique, Westinghouse found that some of that valuable simulator time was being spent by the operators of foreign plants learning the control board configuration of the simulated plant. Naturally, it is everyone's goal to spend valuable simulator time in dynamic interaction with the machine and one's operating team.

Training Tool

A control board mock-up is a scaled down, static model of a control board, generally reduced 50% in size from the actual board. It contains high resolution photographs of the real control board (or the simulator, which is identical), mounted onto a panel which replicates the physical characteristics and dimensions of the control board panel. All of the photographs are covered with clear plexiglass, which allows the instructor to mark or accent controls and instruments with a grease pen.

The mock-up is made by photographing discreet sections of the simulator panels while the simulator is operating under full power, normal conditions. The photographs are reduced in size, developed, and spliced so that there is no apparent joint between one photo and another. These are then mounted/cemented onto the mock-up panel, and final detailing is performed with an air brush. After detailing is completed, the panels are covered with plexiglass.

Outcome

The original intent of the control room mock-up was to familiarize operators from a different plant with the simulator's control board configuration prior to beginning training on the simulator. This goal was accomplished. In terms of cost/benefit analysis, the mock-up appeared to be a worthy investment; at a cost of $14,000, the mock-up would pay for itself by making 28 or more hours of simulator training more valuable. Considering that the simulator was being used for training over 6,000 hours per year, the mock-up provided ample return on investment within its first three months of use.

Several unforeseen benefits were also realized. Perhaps the greatest benefit entails the manner in which simulator training is conducted. Typically, a three person crew is trained for an eight hour shift by one or two instructors. The eight hour shift is comprised of one hour of seminar introduction, six hours of actual simulator operation, and one hour of post operations critique. Since the mock-up is housed in the seminar meeting room, instructors and students alike quickly began utilizing it to increase

the value of the pre and post operations seminars, especially the critique sessions involving discussions of specific instrumentation and controls which were used during the actual simulator scenario. Overall, the mock–up has become so entrenched in the teaching styles of the instructors during seminar sessions that its removal would be unthinkable.

A second advantage of the mock–up is that Westinghouse was once again approached by plants to provide training tools of a similar nature. As our customer/clients saw the mock–up, they requested that Westinghouse provide them a quotation for a similar mock–up which would replicate their control board. In the interim, Westinghouse has sold about 6 control board mock–ups, recovering enough profit to nearly offset the entire cost of their original mock–up.

Computer Based Training

The Need

The Nuclear Service Division of Westinghouse performs a vast array of technical support services at nuclear power plants throughout the nation and the world. In most cases, it is essential for the service workers to have unescorted access within the power plant, since dedicating a utility employee to chaperon the Westinghouse employee would be inefficient. In order for them to have unescorted access, each employee must pass an industry sanctioned course termed NGET (Nuclear General Employee Training). NGET depicts various aspects of radiation safety and instructs individuals regarding access areas and evacuation procedures. After an individual has initially passed an NGET program, he or she must requalify each year.

Westinghouse, as well as all nuclear utilities, delivers NGET training. Since the Nuclear Service Division makes its living by being responsive to the needs of its clients, it was beneficial for Westinghouse to train and qualify the employees of its service division so that when dispatched to a customer site they might be immediately productive. Given this goal, Westinghouse faced a number of concerns:

- The initial qualification class for NGET required 12 hours of student contact time.
- Annual requalification classes required 4 hours of student contact time.
- Typically, classes were held once per month at the corporate headquarters in Pittsburgh. Since so many of the service division's 1,600 employees spend time at customer sites, scheduling everyone for annual requalification became a difficult to impossible task.
- When an employee was required in the field, but had missed his or her requalification, the person often had to sit at a utility site waiting for the next NGET class to convene. This could entail a wait of up to three days, hardly the responsive manner needed to assist a utility in a desperate situation.

Training Tool

In 1984, Westinghouse developed a computer based training NGET program designed to meet all industry criteria and standards. The computer aided instruction features of the program included: high resolution, color graphics, animations, touch screen interaction, help sequences for those requiring further depth upon a subject, and expanded loops that require a student to re–examine certain topical areas in which the desired level of competency had not been achieved. Naturally, the training was self–paced and competency based. The computer managed features of the training entailed: possibilities for students to challenge any module's exam or the final exam; exams that were randomly generated from a proven exam bank of questions, hence no two students would ever see the same exam; and methods for the instructor to record and hard copy document all student responses, scores, and records. An additional CMI feature was to allow the instructors to access and record data at any remote Westinghouse site via telephone connection to Pittsburgh.

Development of the computerized NGET program was accomplished by teamwork in sequential steps.

1. Subject matter experts utilized the industry accepted job/task analysis plus objectives to develop modular lessons and a comprehensive exam bank.
2. Instructional technologists used the subject matter expert's input to script or

storyboard the modularized lessons, including help sequences and assistance loops.

3. Computer programmers, well versed with the software and hardware features of the computer being utilized, programmed the scripts.
4. The subject matter experts reviewed, revised, and approved the final script and lessons.

An overriding concern of the program was to assure that it would be non– threatening, easy to use, and fun! Perhaps the greatest reward for the authors was the positive feedback received from the users, attesting to their enjoyment of the program.

Outcomes

- Design and development of the program cost $87,000. Hardware for the program, located in Pittsburgh and at several remote sites, cost $38,000. Hence, the total investment for the program was approximately $125,000.
- Initial training time for NGET decreased from 12 hours per person to an average of 6.8 hours.
- Requalification training time decreased from 4 hours to 1.9 hours per person per year.
- Since the CBT program was available to employees 24 hours per day, 365 days per year, the number of employees missing their annual requalification time window dropped to almost nil. In accordance, the average wait at a plant site for training dropped from 11.3 hours to 0.5 hours.
- Considering the training requirements of a 1,600 person division, savings in manpower time due to CBT accounted for an annual budget savings of $320,700 per year. Clearly, this training tool has been cost effective in a sterling manner. In addition, it has increased efficiency and proven to be fun for the trainees.

Interactive Video Disk

The Need

As previously stated, a nuclear power plant is a very complex assembly of piping and instrumentation. Operators, security guards, and maintenance workers must be intimately familiar with the design and location of all aspects of the plant. Yet, such a charter is not so simple to implement, since once a plant has become operational, certain areas are barred from access for security and radiation reasons. That is to say, individuals who were present during plant construction may have had the opportunity to explore every nook and cranny of the plant site. However, those hired after the plant became operational may not be allowed access to certain areas, even though they are required to know design and component locations. Hence, there is a great need to present plant architecture and layout in an easy to understand and realistic way.

Training Tool

Recent technology has provided us with the videodisc, a high resolution laser disc capable of storing 54,000 images per side. Its capability became a natural match for providing nuclear power plant surrogate tours.

Ideally, as a nuclear power plant is completed, but before fuel is loaded, a filming crew will enter the plant and take a series of pictures. Essentially, the filming crew walks all areas of the plant, taking six pictures every foot. These are taken in every direction facing forward, backward, right, left, up, and down.

The pictures are then imprinted upon the video disk and accessed by specialized computer software that allows a person to "tour" the plant via joystick control. That is, by pushing the joystick forward, the person walks forward one foot at a time. Similarly, the he or she look or walk left, right, or backward by joystick control. In addition, the person can stop and look up or down at any point along the tour. Actual pictures are displayed on a television screen while the traveler's location is continuously updated in regard to a graphic plant layout on the computer's CRT. At any time, the traveler can change his or her

location completely by accessing the program to leap to another part of the plant.

Additional software capsbilities of the surrogate tour system include:

- word and/or arrow graphic overlays to highlight select parts of certain components;
- telephoto zoom capability to expand areas of the picture one is viewing;
- voice overlay to describe a component or a process; and
- video tape insertion to explain and demonstrate (to a maintenance person, for example) the process of teardown, repair, and reassembly of a valve.

Overall, the videodisc surrogate tour allows tremendous flexibility and customization for the unique needs of special audiences.

Outcome

The videodisc surrogate tour has been quickly embraced by the the industry as a standard for maintenance, security, and operations training. At the move of a hand anyone can determine the most expedient route to a component, surroundings of the component, and the tools or equipment necessary to service that component. The following two examples detail the cost benefit analysis of utilizing the videodisc surrogate tour for training and education:

The Perry power plant, owned and operated by Cleveland Electric Illuminating, was scheduled to become operational only a short time before an earthquake shook the Cleveland area. Industry regulators and newsmedia alike questioned the safety of the plant during earthquake conditions, thus causing a temporary delay of plant startup. Utilizing the videodisc tour, Perry management was able to quickly and emphatically assure all concerned that the plant design was completely adequate for earthquakes of relatively large magnitude. The plant was permitted to proceed with its startup in a very expedient timeframe. Considering that an operating plant generates about $1,000,000 of revenue per day, the $100,000 cost of the videodisc tour was a sound investment for this unique incident alone, not to mention the day–to–day value of training security and maintenance personnel.

The Joseph M. Farley plant, owned and operated by Alabama Power Company, utilized a videodisc tour to train contract workers who would be assisting in a refueling outage. The workers used the video disk tour to learn plant locations, the most expedient path leading to a location, and necessary tools and considerations for performing maintenance functions, all before entering the plant. Overall, the refueling outage proceeded efficiently because the contractor personnel "knew" the plant before they entered it. Again, with operating revenues of nearly $1,000,000 per day, the $100,000 cost of a videodisc tour appears a very worthwhile investment.

Partial Scope Simulation

The Need

A nuclear power plant transforms the heat energy of fission into electrical energy. Operators of the plant must understand and apply a variety of engineering principles to assure safe and efficient plant operation. Plant operation is a dynamic, interrelated process. Changing one parameter can effect numerous other parameters throughout the plant. This operational process parallel in some ways to driving; one can read and study about driving yet can never experience it until he or she actually operates a vehicle. Additionally, operating a vehicle in busy city traffic is yet a new experience for the novice driver, since one has to compensate for the driving practices of all other drivers.

Within a nuclear power plant, a valve misalignment or a pump failure can cascade into a multitude of changes throughout the plant. Temperature, pressure, and reactivity can all change quickly and drastically as a result of diminished core cooling flow. Operators read and study these facts, but until one has experienced such a dynamic event, the impact or the complex interrelationships of the situation can

not be fully comprehended. For that reason, control room simulators have become an integral part of training nuclear power plant operators. Unfortunately, not every utility can afford to purchase a $10–14 million simulator, along with the building in which to house it and maintenance and teacing staff.

Training Tool

A cost effective option to a full scope simulator is a partial scope simulator. Rather than replicating precisely the control boards and instrumentation of the reference plant, the partial scope simulator models a select number of the plant's more important systems and controls, but not necessarily in perfect congruence to the original control board layout. The key to the partial scope simulator is in the software modeling capabilities. Operators can witness the effects of one or multiple malfunctions of plant components. Operators can see how the plant will respond to a variety of abnormal or emergency conditions and thereby learn how they must respond in accordance to those situations.

The partial scope simulator consists of an abbreviated control board, approximately 15 to 20 feet long, and an engineering computer. Most of the plant's principal systems and components are modeled, but not every system. Similarly, there are controls and instruments that govern these systems, but they are not necessarily configured in the same manner as the plant's control board. However, operational setpoints, limit indicators, and the like are modeled into the software to parallel the reference plant. Operators can witness plant responses and control plant operations through the dynamic interchange of sophisticated simulation. Although partial scope simulators vary in cost by specific design, an average price is $4–7 million.

Outcome

NOK is the Swiss utility that owns and operates the Beznau nuclear power plant. Operators from NOK's Beznau/Nordostschweizerische Kraftwerke AG plant have returned to Westinghouse for annual requalification every year since the plant became operational. This has been a cost effective means of training, since NOK is a relatively small plant with a lower number of operators and a very stable operator population. However, participation in simulator training only once each year is not always the ideal situation.

NOK recently purchased a partial scope simulator for approximately $4.5 million and utilizes the partial scope simulator to augment its formalized classroom retraining and study in Switzerland. Operators can witness and respond to various malfunctions and emergencies via the partial scope simulator. They will continue to return to the United States annually to retrain on the full scope simulator. Is their partial scope simulator worth the $4.5 million investment? A smaller plant like NOK is capable of generating about $500,000 of revenues per day. If the simulator enhances plant availability (the utility term for having a plant capable of generating electricity) for nine additional days, it will pay for itself. This appears to be a fairly safe bet over the remaining 20 year lifespan of the plant. Regardless, the Swiss have already indicated that it was worth every penny (or in their case, every franc).

Artificial Intelligence

The introduction of artificial intelligence into the nuclear industry has been heralded with wide acceptance and acclaim. Artificial intelligence (AI) is "a computerized process that attempts to emulate the human thought processes associated with activities that require the use of intelligence" (Uhrig, 1987). The principal thrusts of AI within the nuclear industry have been to develop "expert systems"; that is, computerized systems capable of applying the knowledge and logic of an expert to a particular subject or topical area. The nuclear industry is, of course, excited about expert systems that may consolidate the experience and wisdom of specialists in a transportable fashion, available at any time. Stated in another way, the expert insight and judgment of a specialist is available without the specialist being physically present.

A survey of AI applications within the nuclear industry was compiled by Robert Uhrig for presentation to the American Nuclear Society in 1987. The applications vary widely by topic and subject area, but show a common thread of providing diagnostic or analytical trouble shooting expertise regarding engineering problems. At this time there does not appear to be any AI system implemented strictly for

training purposes within the nuclear industry. However, it is understandable that the principles and benefits of AI could be applied to training needs. The following two excerpts will give examples of how AI is being used today in the nuclear power industry.

The Westinghouse Hanford Company in Richland, WA has developed an AI expert system designated CLEO (clone of Leo). Leo is the resident expert in refueling operations, possessing considerable specialty knowledge in the best possible manner to configure and load fuel into Hanford's Fast Flux Test facility reactor core. In Leo's absence, CLEO selects the best possible strategy for fuel loading and generates a list of necessary refueling moves based upon the reactor physics data. CLEO takes into account the physics parameters of the existing core and the desired physics conditions of the new core and then generates data in less than 30 seconds.

Also at the Westinghouse Hanford Company's FFTF is a second AI expert system designated CRAW. CRAW is responsible for diagnosing fuel cladding failures based upon gas detection, metallurgical analysis, chemical analysis, and the like. Typically, a resident expert must be on site 24 hours a day in order to perform this analytic function. CRAW has proven to be an effective substitute when no resident expert is available.

Outcome

In both of the aforementioned cases, diagnostic and analytical trouble shooting expertise has become available without human presence. Although these expert systems are in their infancy and are subject to upgrade and refinement, each AI system is performing an essential task through the application of advanced technology. At this point we cannot create or expand upon the knowledge and logic of the expert, but we can emulate his or her thought processes, thereby creating an acceptable substitute for constant human presence.

The role of the trainer often enters analytical and diagnostic realms. We diagnose learning difficulties or analyze why a student is not comprehending a concept or applying a theory. Conventional computer based training does a laudable job of delivering instruction and even offering help or expanded learning loops. However, it is not presently capable of diagnosing learner problems or special needs. No doubt, the future holds a merger of computerized delivery techniques with instructional expert systems. The computer will not only deliver the concept, but may also analyze why the student did not grasp the concept and compensate instructional techniques in accordance to its diagnosis.

Full Scope Simulation

The Need

A large nuclear power plant is operated by a staff of 300 to 600 people. Included in a typical plant staff is: a health physics department, a radiochemistry department, an electrical maintenance department, a mechanical maintenance department, an instrumentation and control department, a tech staff/engineering department, and an operations department. As the name implies, the operations department is responsible for all aspects of day-to-day plant operation. At the heart of the operations department are the licensed operators, those individuals entrusted with overall plant operation and licensed by the federal government (Nuclear Regulatory Commission) to operate the plant in a safe manner at all times.

Licensed operators have tremendous responsibilities. Their decisions and their actions affect every aspect of plant safety and efficiency. Should a licensed operator make a mistake, it could have severe ramifications for worker and public safety, and/or it could cost the utility millions of dollars in plant down time. In addition, utilities can be fined for operational errors, licensed operators can have their licenses revoked, or the operators can be fined personally for operational errors. Given all of this, one can see why it is imperative to qualify and requalify the licensed operator so that his or her skills remain current and honed to a fine edge.

The nerve center of a nuclear power plant is the control room. The control room is typically staffed by a three person crew. By law, at least two members of this team have to be licensed operators, but most utilities require all three persons to be licensed. This crew works together as a team; therefore, skills such as communication, delegation, feedback, and team dependent behavior are important. The goal,

of course, is to train and retrain the team so they may safely respond to any situation—from a single malfunction to a complex casualty involving multiple malfunctions. However, it is also everyone's goal that no team ever encounter such situations while operating the plant. The need, then, evolves to a training tool so realistic that it replicates the plant control room in every detail and dynamic response yet in no way is the plant itself ever placed in an adverse or jeopardized position for the sake of training.

Training Tool

The ultimate audiovisual training tool for licensed operators is the full scope simulator. A full scope simulator replicates the control room in every detail but the replicated control room is not hooked to the plant—it is hooked to a computer. Through the use of sophisticated software and complex math models, the simulator replicates actual plant response to normal, abnormal, and emergency conditions in exacting precision. As one might imagine, some of the emergency conditions are the result of exhaustive engineering and computer studies. A typical full scope simulator costs between $10–14 million Because it is an exact replica of a unique and specific plant, it requires about 30 to 36 calendar months to build, utilizing about 50 to 70 person years of sophisticated, specialized expertise. The fine tuning and acceptance testing time alone requires 6 months at the end of construction. Once the simulator is installed, it requires a staff of 10 to 14 people: 6 to 8 licensed or certified instructors, 1 or 2 hardware support engineers, and 2 or 3 software support engineers. Regardless of the simulator's fidelity, it can always be improved a little bit more. Math models can be fine tuned, software programs can be rewritten, instructor features can be enhanced, and certain new programs and models must be written to assure that the machine can simulate and thereby train operators on recent industry events at other plants.

Training on the simulator always involves the full operational crew of three people plus one or two instructors. The instructional content will vary depending on plant conditions, individual needs of the crew, and annual requalification requirements. For example, a large nuclear plant generally refuels once a year, starts up, and then runs for 250 to 300 days at full power until it is time to refuel again. As such, a standard reactor start–up may be one of the simulated exercises, since this is typically done on the plant only once per year, and it is performed by only one of the six operational crews who rotate shifts for the plant's seven day per week, 52 week per year operation. More often than not, however, simulator training involves the instructor programming multiple malfunctions into the simulator to allow the crew to analyze and diagnose problems; often reaching—as a team—the synthesis and evaluation levels of the cognitive domain. The simulator runs at "real time"; that is, in the exact same time that actual plant events would occur. Often, though, the instructors will stop or freeze the simulator to allow discussion of an important point or to focus upon an important parameter. The simulator can also be backed up. For example, if the crew has continued into a scenario for 45 minutes or so and does not have full comprehension of all events and concepts, the instructor can back up the simulator in 3 or 5 minute increments and ask, "What's happening now with temperature, with pressure, with feed flow level, etc.?" This allows trainees to spend time on task and focus upon important parameters of operation. Finally, training sessions are generally videotaped. This allows the instructors and the crews themselves to critique the critical aspects of team dependent behavior, such as communications, delegation, compliance to procedures, etc. Overall, simulator training is a dynamic experience that, at times, is very intense and taxing. No two sessions need ever be alike.

Outcome

When a utility purchases a $12 million simulator, that is only the beginning of the investment. The utility, at a minimum, must build a training center to house the simulator, hire and train a staff to conduct training, and develop curriculum materials to use in training. When all is said and done, the investment could be $15 to $20 million. How can one justify such an investment?

The financial outcome of Three Mile Island or Chernobyl provides sobering figures to utility management and (in the case of Three Mile Island) the stock investors. Succinctly put, $20 million is a drop in the bucket compared to the financial burden

embraced by these two plants. This does not even investigate the safety and social ramifications of those two accidents, aspects which dwarf the financial concerns in importance. However, dwelling on the negative leads us to an avoidance or fear motivation. What can we say about the desirable outcomes of utilizing a plant specific simulator on a regular basis?

Within the past four years, the majority of United States nuclear power plants have gone from training on a nonplant specific simulator once per year to training on their own plant specific simulator several times per year. In this same period of time, industry statistics show (INPO, 1987):

- plant availability (the amount of time plants are able to produce electricity) is up 2%;
- inadvertent trips (having the reactor automatically shut down when one did not intend to shut it down) has decreased by 40%;
- unplanned safety system actuations (the number of times emergency systems are automatically initiated by the plant computer due to loss of power to a safeguard system) has diminished 31%;
- gross heat rate (an efficiently operated plant will use less thermal heat to produce equivalent electricity) has declined 1%; and
- lost time accident rate (worker injuries) has decreased 53%.

Can one justify the investment? Considering a plant can produce $1 million of revenue per day, a simulator that may keep a plant on line one extra day a year will pay for itself in ten to fourteen years. Ideally, it will keep the plant on line more than one extra day per year (as the statistics are indicating) and pay for itself in far less than a decade. One can put things in perspective in another manner by referencing the old adage, "If one thinks education is expensive, one only need calculate the price of ignorance."

Conclusion

The purpose of these descriptions of training technologies used in the nuclear power industry was neither to praise nor condemn the industry. Rather, the intent was to reference the actual implementation of training tools within an industrial training environment. Simply stated, the goal of any industrial training organization is to assure mastery of skills, knowledge, and performance in the most cost effective manner possible. In many cases, a less sophisticated tool will assure competence. However, in certain specialty areas, only the most sophisticated and dynamic training tools will fill the need. It is all a matter of scale; will the benefits (financial, safety, social impact, or whatever) outweigh the costs?

Computer aided training tools are both currently implemented and still evolving within the nuclear power industry. When developed and applied correctly, these tools ensure mastery of training objectives in a cost effective, well documented, and often self–paced manner. The sophistication of the tool varies from the hand held Study Pac (perhaps one generation beyond the calculator) to full scope simulators. Nonetheless, this seeming praise is not meant to establish computerized training tools as a panacea for industrial and vocational training. In this chapter, we have concentrated upon the success stories. Unfortunately, there are a number of unsuccessful stories within the industry as well. Specifically, one can find several electric utilities who are strongly opposed to computer assisted training tools because their first and only experience was painful—painful to the extent that the training tool did not reach its objective, that trainees dreaded the training and their interaction with the training tool, and the tool was very expensive. Similar to the folklore of the ancient mariner, who was forced to wear an albatross around his neck, many utility training managers have had their unsuccessful computer training experiments bronzed or perhaps placed upon pedestals with spotlights by their upper management to serve as constant reminders of the money that was wasted and the agony that ensued from their new–fangled, computerized toy. The bottom line is that sophisticated training tools are only as effective as the up front analysis, planning, and design that precedes them.

In the final analysis, though, the successes are outweighing the failures, and the power and sophistication of computerized training tools is growing rapidly. Some predictions for the future include the following (Widen, Mangan & Weiss, 1987).

- The amount of computer based courseware will continue to expand in both quantity and sophistication.

- Courseware transportability from one type of hardware to another will become commonplace. That is to say, powerful "translation" software will allow courseware developed on one hardware system to run with equal capability on another.
- Enhanced technology, such as stronger software languages and graphics digitizers, will lessen computer based training development costs.
- Videodisc technology and voice synthesizers will become standard components of CBT lessons.
- Artificial intelligence will play an increasingly important and integral role in computer based training.
- Simulation devices will continue to evolve in sophistication and fidelity.

In many ways we stand at the frontier of this form of training. The discoveries and applications to date have been rewarding and meaningful, but there are many exciting developments yet to come. Despite this, it is important not to fall into the trap of waiting for the next generation of hardware, software, or authoring ease. Computer based training tools can and do meet a broad spectrum of vocational training objectives today. These computer aided tools are powerful, cost effective, and fun!